TEXAS HORNSHELL

Popenaias popeii

RECOVERY PLAN

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EXECUTIVE SUMMARY

This Recovery Plan is for Texas hornshell *Popenaias popeii,* a freshwater mussel native to the Pecos River and Rio Grande drainages in New Mexico, Texas, and Mexico. The species currently occupies about 12% of its historic range in New Mexico, where the population is limited to a 9 mile reach of the Black River in Eddy County. In the Black River, Texas hornshell are found in crevices under travertine shelves and boulders where soft sediment gathers. Water quality and quantity is an important component of Texas hornshell habitat and changes to habitat, especially pollution, siltation, and loss of flowing water, may have contributed to population loss throughout the historic range.

Freshwater mussels have a unique life cycle that requires specific host fishes to complete. Larval Texas hornshell attach to suitable fish hosts to survive and transform into adult mussels. This trait allows mussels to move while attached to fish, but also makes them more susceptible to population declines associated with declines of host fish species. Texas hornshell, like all mussels, are filter feeders, which increases their sensitivity to water pollution.

Recent studies indicate that the Texas hornshell population found in the Black River is stable, but historic habitat outside of this area is not currently appropriate for occupancy. Recommendations for Texas hornshell recovery include conservation of current populations through habitat protection and restoration of historical populations and habitats. Recovery actions under the Wildlife Conservation Act and this plan are voluntary and cooperative. Therefore, one of the primary recommendations for recovery is coordinating actions across the watershed, including supporting private landowners and land management agencies in habitat management activities that will benefit Texas hornshell.

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1 INTRODUCTION

This recovery plan (Plan) was developed under the authority of the New Mexico Wildlife Conservation Act (WCA) amendments of 1995, which direct the New Mexico Department of Game and Fish (NMDGF) to formulate recovery plans for species listed as State threatened or endangered [17-2-40.1 NMSA 1978]. The WCA states that each recovery plan should: 1) restore and maintain viable populations of a listed species and its habitat, such that the species may be delisted; 2) mitigate adverse social or economic impacts resulting from recovery actions; 3) identify social or economic benefits and opportunities; and 4) use existing resources and funding sources, to the extent possible, to implement the plan.

This Plan addresses the recovery of the Texas hornshell *Popenaias popeii*, a native mussel, listed as endangered in New Mexico [19.33.6 NMAC]. As required by the WCA, a public information meeting was held in Carlsbad, New Mexico, on 7 September 2006 to initiate the planning process. The Advisory Committee for this Plan includes representatives from U.S. Fish and Wildlife Service, Bureau of Land Management, Natural Resources Conservation Service, New Mexico Environment Department, State Lands Office, Carlsbad Soil and Water Conservation District, University of Miami (Ohio), Center for Biological Diversity, SWCA, Inc., and private citizens. Further information on public participation and the Advisory Committee is in Appendix I.

The organization of this recovery plan follows the format provided in the NMDGF *Guidelines for Writing Long Range, Action, and Operational Plans* (Graves 2002). Section 1 provides an introduction, including the authority for the Plan. Section 2 of this Plan includes background information on the distribution, habitat requirements, biology, and ecology of Texas hornshell. Also included are an analysis of factors that led to the endangerment of the species and existing and potential threats to the species. Section 3 addresses the goal for recovery of the species, associated objective, and issues and strategies. Section 4 contains the recovery plan implementation schedule.

2 BACKGROUND

Section 2 consists of background information on the distribution, status, habitat requirements, biology, and ecology of Texas hornshell. This information provides the basis for assessing current status, threats to persistence, and the most effective recovery strategies for the species.

2.1 NATURAL HISTORY

2.1.1 Name

Lea (1857) described this freshwater mollusk as *Unio popeii* from the "Devil's River, Texas, and Río Salado, New Leon, Mexicos." The scientific name and the type locality have undergone subsequent revisions (reviewed in Strenth et al. 2004). The current taxonomic authority recognizes the binomial *Popenaias popeii* for this mussel and ascribes its common name as the Texas hornshell (Turgeon et al. 1998).

2.1.2 Description

Bivalve mollusks, which are characterized by two hard shells, include saltwater (clams, mussels) and freshwater (pea- and fingernailclams, mussels) forms. Texas hornshell is a freshwater mussel in the Family Unionidae, often termed pearly mussels or naiads. Freshwater mussels are characterized by a pair of crystallized calcium carbonate shells (valves) secured together by a hinge ligament and processes termed "teeth" (Smith 2001). The internal soft anatomy consists of a visceral mass, incurrent and excurrent siphons for water exchange, two pair of gills for respiration and incubation, and a muscular foot for movement.

Shells of Texas hornshell are trapezoidal and elongate (length-to-height ratio 1.8), laterally compressed, anteriorly rounded and narrow, and posteriorly slightly truncated and wider (Howells et al. 1996; Figure 1). Lang (2001) reported average valve measurements (in millimeters/inches) of live Texas hornshell (n = 89) as: length = 98.0/3.9 (range 55.8-114.0/2.2-4.5), height = 45.1/1.8 (range 25.6-57.7/1.0-2.3), and width = 28.3/1.1 (range 14.8-56.2/0.6-2.2). The umbo, or beak, is raised above the hinge line and is often eroded. The periostracum, or outside surface of the shell, is olive-green to dark brown, sometimes faintly rayed in younger specimens. Internally, the nacre, or inside surface of the shell, varies from glossy to dull white, bluish-white, or purple-gray. The beak cavity is shallow; the two left and one right pseudocardinal teeth are small, and the two left and one right lateral teeth are long, low, and slightly curved.

Glochidia (larvae) of Texas hornshell are semi-elliptical with pitted valves (Figure 2) (Smith et al. 2003). The hinge is long with a well-developed ligament. Teeth are simple and conical, with the largest in the outermost row, decreasing inwardly.

Figure 1. External anatomy of Texas hornshell adult, Black River, New Mexico. Photo: Brian Lang.

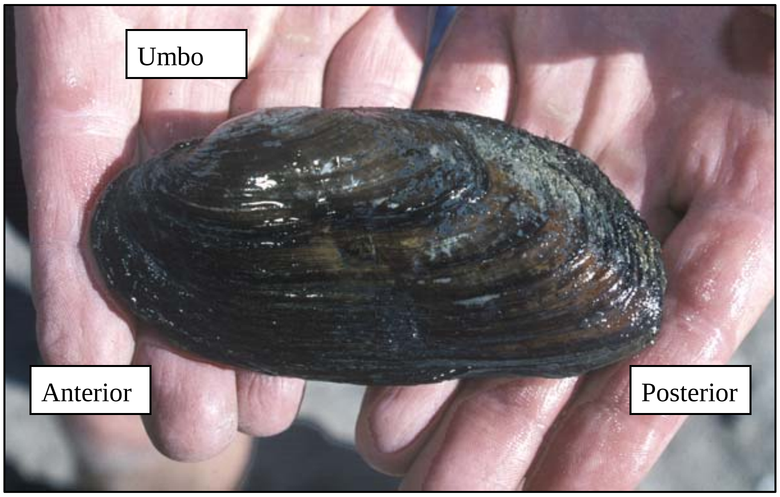
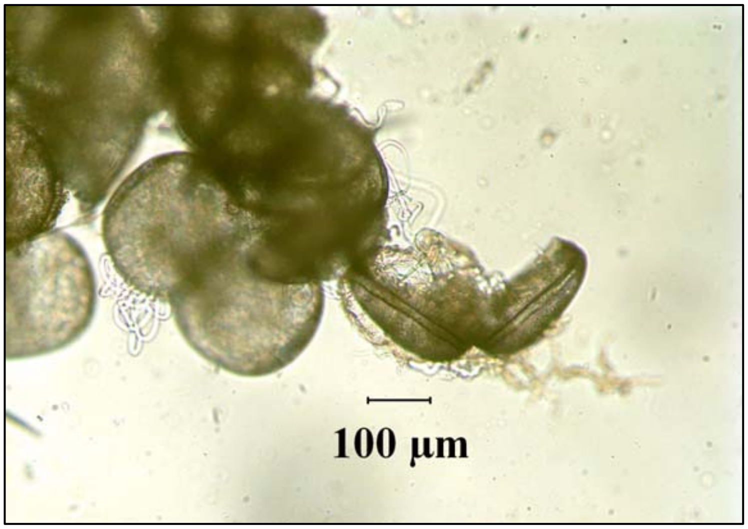


Figure 2. External anatomy of Texas hornshell glochidia, Black River, New Mexico. Photo: Todd Levine.



2.1.3 Taxonomy and Phylogenetic Relationships

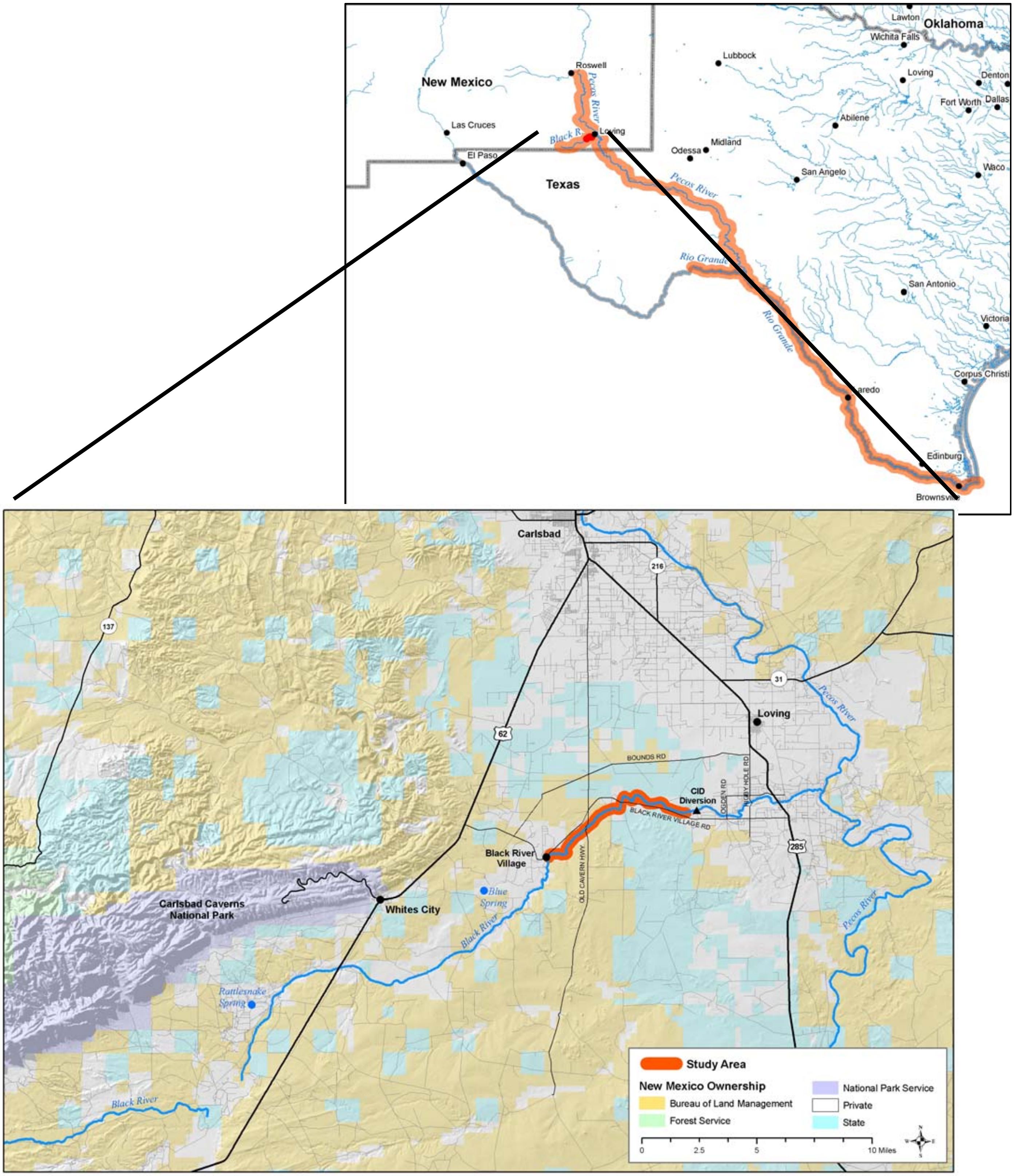
Originally described as *Unio popeii* by Lea in 1857, this species was later placed in the genus *Elliptio* by Ortmann (1912) and afterward given its own subgenus, within the genus *Elliptio* (Frierson 1927). Subsequently, Heard and Guckert (1970) elevated *Popenaias* to genus status and created a new subfamily, the Popenaiadinae, for the genera *Cyrtonaias* and *Popenaias*. Thereafter, Popenaiadinae was dropped on the basis that its diagnostic criteria represented species-specific rather than phylogenetically significant characters (Heard 1974). Currently, this species is classified in the unionid subfamily Ambleminae (Campbell et al. 2005). These variable views of *Popenaias* evolutionary relationships suggest that there is a great deal of uncertainty regarding the phylogenetic placement of the genus (Hoeh et al. 1999).

2.1.4 Historic and Current Distribution

Popenaias popeii is reported from Western Gulf and Mexican Gulf coastal drainages of the Rio Grande Basin south to the northern Estado de Vera Cruz, Mexico (Johnson 1999). In the United States, this mussel occurred historically in the Pecos River system from North Spring River, near Roswell, Chaves County, New Mexico (Cockerell 1902), throughout the Pecos River and in the lower Rio Grande to Brownsville, Cameron County, Texas (Neck and Metcalf 1988, Howells et al. 1996; Figure 3). Recently fresh dead shells were found in the Rio Grande between Big Bend National Park and the mouth of the Pecos River, Texas (Howells and Ansley 1999, Strenth et al. 2004).

Currently, *P. popeii* is known from only two isolated populations in the United States: the Black River, Eddy County, New Mexico (Lang 2001) and the Rio Grande near Laredo, Webb County, Texas (Strenth et al. 2004). The population in New Mexico is confined to a 14 km (8.7 mi) reach of the middle Black River from Black River Village downstream to the Carlsbad Irrigation District (CID) dam, which represents less than 12% of its historic range in New Mexico (Lang 2001; Figure 3).

Figure 3. Historic distribution of Texas hornshell in the United States (orange), with an insert of current study area, where Texas hornshell have been confirmed in New Mexico (red).



2.1.5 Habitat Requirements

In general, filter-feeding mussels require clean, flowing water. As such, freshwater mussels are very sensitive to environmental changes and serve as indicators of aquatic ecosystem health and integrity (Neck 1982, Havik and Marking 1987). Habitat modification, in the form of mainstem impoundments, water diversion, water pollution, and sedimentation, has been linked with the drastic decline of freshwater mussels in North America (Allan and Flecker 1993, Melhop and Vaughn 1993, Neves 1993, Williams et al. 1993, Ricciardi and Rasmussen 1999).

Habitat affinities of adult Texas hornshell have been extensively studied in the Black River (Lang 2001, 2004, 2005, 2006). Adult Texas hornshell are most often located in crevices, undercut riverbanks, travertine shelves, and under large boulders, where small-grained material, such as clay, silt, or sand, gathers and provides suitable substrata for anchoring. These protected areas appear to serve as “flow refuges” (Strayer 1999b), where Texas hornshell remain secure during large volume spates (Lang 2001). Texas hornshell is not known from impoundments (Metcalf 1982, Neck and Metcalf 1988, Howells et al. 1996), and the presence of low-head dams appears to limit its habitat and distribution in the Black River, possibly by restricting movement of host fish or smothering of habitat by excessive silt deposition (Lang 2001).

Habitat preferences of juvenile Texas hornshell have not been described, but likely are similar to preferences of other species of freshwater mussels, which are found interstitially in small-grained substrates (Yeager and Cherry 1994).

Water quality is an important component of Texas hornshell habitat and changes in water quality may have contributed to population loss throughout the historic range. Salinity in particular is thought to limit Texas hornshell distribution. Laboratory studies indicate that Texas hornshell show behavioral signs of physiological stress, followed by death, at a salinity of 7.0 ppt (Lang 2001). Salinity in the occupied area of the Black River is around 0.9 ppt, but increases significantly downstream of the CID Dam to 2.8 ppt. Salinities in the Pecos River downstream of the Black River confluence range from 6.0-7.0 ppt (Lang 2001).

Although some species may be more tolerant, dissolved oxygen levels below 20% saturation are stressful to freshwater mussels (Ellis 1937, Ingram 1957, Imlay 1971). Over a 10-month period (March-December 2003), the New Mexico Environment Department (NMED) recorded monthly dissolved oxygen (DO) in occupied habitat from 7.07 to 0.88 mg/L (T_{water} = 10.78-26.77°C), indicating DO saturation between 77 and 115% (S. Stringer, NMED, *pers.comm*. March 2007). New Mexico Department of Game and Fish sampling (1996-2000) indicated an average DO of 6.9 mg/L (range = 3.4 to 13.8) in occupied habitat (Table 1; Lang 2001).

Freshwater mussels, especially juveniles, are very sensitive to common pollutants such as ammonia and chlorine and metals such as copper (see Havlik and Marking 1987 for a review). Toxicity levels of these pollutants are not known for Texas hornshell and this information may be important for protection and rehabilitation of habitat. Recent publications have suggested that to protect freshwater mussels, federal water quality criteria for ammonia should be changed from 1.24 mg/L total ammonia as nitrogen at pH 8 and 25°C to between 0.3 to 1.0 mg/L (Augspurger et al. 2003). The New Mexico Environment Department recorded ammonia from 0.1 to 0.122 mg/L in the Black River just below occupied habitat in 2003 (S. Stringer, NMED, *pers.comm*. March 2007). Copper levels in the Black River are currently below detectable levels and chlorine is not tested (S. Stringer, NMED, *pers.comm*. April 2007). To date, levels of ammonia, chlorine, and metals have not been tested within occupied habitat.

Table 1. Mean physiochemical parameters in current (*) and historic Texas hornshell habitat, 1996-2000. The range of each parameter is listed parenthetically with sample size (n=). Reproduced from Lang 2001.

River Reach	**Temperature °C**	**pH**	**Specific Conductance µS/cm**	**Salinity ppt**	**Total Dissolved Solids Kmg/L**	**Dissolved Oxygen mg/L**
Black River upstream of CID dam * (n=41)	22.6 (5.5-32.3)	8.0 (7.3-8.5)	1647 (686-4820)	0.9 (0.3-2.7)	1054 (393-3085)	6.9 (3.4-13.8)
Black River downstream of CID dam (n=3)	25.9 (23.8-27.3)	7.8 (7.3-8.5)	5030 (4065-6205)	2.8 (2.2-3.4)	3219 (2602-3971)	8.4 (7.7-9.4)
Pecos River (n=19)	27.1 (21.4-32.8)	8.1 (7.5-8.5)	4567 (1780-13,500)	2.3 (0.9-6.1)	2923 (1139-8640)	7.6 (6.5-8.9)
Delaware River (n=4)	23.2 (22.0-24.3)	7.7 (7.2-7.8)	3220 (2937-3488)	1.8 (1.6-1.9)	2061 (1880-2232)	7.4 (2.7-9.2)

Freshwater mussels require perennially wetted habitats; emersion (stranding) causes dehydration and death, although length of time to mortality varies by species (Coker 1919, Strecker 1931). Drought has been shown to cause extirpation of several species, both by emersion and loss of fish hosts (Metcalf 1983). In occupied habitat, flows vary greatly, but habitat is always inundated. The USGS gage on the Black River above Malaga (08405500), located within Texas hornshell habitat, has been in operation since 1947, during which time daily flows averaged 12.8 cubic feet per second (cfs). While extreme flows have been recorded (12,000 cfs, 23 August 1966; 0.01 cfs, 30 September 1998), a more realistic hydrograph of the Black River is represented during the period 2002-2006 when mean daily discharge ranged from 2.6 to 912 cfs (overall mean = 10.1 cfs).

2.1.6 Food Habits

Like all adult freshwater mussels, Texas hornshell are filter feeders, siphoning seston (suspended bacteria, plankton, organic and inorganic material) from the water column (James 1987, Smith 2001). Increasing evidence indicates that "deposit feeding" by adult mussels (filtering interstitial water, pedal or foot feeding) may provide a significant proportion of the total food energy for adult mussels (Vaughn and Hakenkamp 2001, references therein). Juvenile Texas hornshell most likely "pedal feed", using the foot to sweep organic and inorganic particles found among substrata into the pedal gape (Reid et al. 1992, Yeager and Cherry 1994). Larval Texas hornshell are obligate parasites on fish (see Section 2.1.7 for more information).

2.1.7 Reproductive Biology and Growth

Texas hornshell are dioecious (separate sex) mussels. Spawning is asynchronous, meaning that mussels may be in various stages of reproductive condition during a single breeding season. Gametogenesis (production of eggs and sperm) occurs from January through September in the Black River (Lang 2001, Smith et al. 2003). Females produce ova that are held in the gill mantle chamber. Ova are fertilized by sperm, which are released into the water column by males and then taken in through the incurrent siphon of the female. Developing zygotes are held in brood pouches of the gills (marsupia) for four to six weeks (Smith et al. 2003). Females are gravid from late April to early August.

Once developed, larval Texas hornshell, called glochidia, are released by the female as conglutinates in a sticky mucous mass or string. Glochidia are obligate parasites on fish and attach to the gills, fins, or head of appropriate host species where they encyst and feed off of the host's body fluids. In laboratory-induced infestations, Texas hornshell glochidia metamorphosed as juvenile mussels from 26 of 31 species of fish (Table 2) over a period of six to fourteen days (Gordon et al. In review). These laboratory results, while useful for identifying "physiological hosts", do not provide conclusive evidence of ecologically relevant hosts in the wild (Berg and Levine 2006a, Gordon et al. In Review). Various biotic factors, such as acquired immunity from prior exposure to glochidia (O'Connell and Neves 1999, Rogers and Dimock 2003, Dodd 2005) or other parasites (e.g., copepods; Arey 1923) and fish habitat use or feeding behavior, may influence glochidial-host relations. The New Mexico Department of Game and Fish is currently investigating ecological hosts for Texas hornshell. Preliminary results indicate that encysted glochidia have been confirmed on seven fish species in the Black River: gizzard shad *Dorosoma cepedianum*, red shiner *Cyprinella lutrensis*, river carpsucker *Carpiodes carpio*, blue sucker *Cycleptus elongates* (state endangered), grey redhorse *Moxostoma congestum* (state threatened), channel catfish *Ictalurus punctatus* (nonnative in the Black River), and longear sunfish *Lepomis megalotis* (Berg and Levine 2006a).

Little growth occurs during the glochidial stage; most mussels tend to grow rapidly as juveniles then slow as they reach maturity (Smith 2001). Based on shell measurements of recaptured adult mussels, growth of Texas hornshell is less than 1.0 mm (0.04 in) per year (Lang 2001). Texas hornshell smaller than 35 mm (1.4 in) shell length have not been recorded in the Black River (Lang 2001), which may represent an artifact of sampling bias rather than lack of recruitment. Mussels of the subfamily Ambleminae like Texas hornshell, commonly live over 20 years (Stansbery 1967).

2.1.8 General Habits

Long distance movements of Texas hornshell appears primarily restricted to the larval stage, when encysted glochidia are transported passively by host fish. Adult mussels move by thrusts and pulls of the foot (Smith 2001) and when either intentionally or unintentionally dislodged. Intentional movements are thought to be in response primarily to cessation of flow and decreased

Table 2. Fish of the Pecos and Black rivers, indicating presence (X=Extant, (X)=Extirpated), Status (I=Introduced, FE=Federally Endangered, FT=Federally Threatened, SE=State Endangered, ST= State Threatened), and Suitability as a Host Fish for Texas hornshell in the Lab and Field (Y=Yes, U=Uncertain, N=No). Compiled from Cowley and Sublette 1987, Sublette et al.1990, Lang 2004, 2005, 2006, and Gordon et al. In Review.

Common Name	Scientific Name	Pecos River	Black River	Status	Lab Host	Observed infected in the Wild
American eel	*Anguilla rostrata*	(X)				
Spotted gar	*Lepisosteus oculatus*	(X)				
Longnose gar	*Lepisosteus ossesus*	X	X		Y	
Rainbow trout	*Oncorhynchus mykiss*	X	X	I		
Gizzard shad	*Dorosoma cepedianum*	X	X			Y
Northern pike	*Esox lucius*	X		I		
Mexican tetra	*Astyanaz mexicanus*	X		ST	Y	
Goldfish	*Carassius auratus*		X	I		
Red shiner	*Cyprinella lutrensis*	X	X		Y	Y
Common carp	*Cyprinus carpio*	X	X		Y	
Roundnose minnow	*Dionda episcopa*	X	X		Y	
Rio Grande chub	*Gila pandora*	X				
Rio Grande silvery minnow	*Hybognathus amarus*	(X)		FE, SE		
Plains minnow	*Hybognathus placitus*	X			Y	
Speckled chub	*Macrhybopsis aestivalis*	X			Y	
Golden shiner	*Notemigonus crysoleucas*	X		I		
Arkansas River shiner	*Notropis girardi*	X		I, FT, SE		
Rio Grande shiner	*Notropis jemezanus*	X	X	FT, SE	Y	
Pecos bluntnose shiner	*Notropis simus pecosensis*	X		FT, ST		
Sand shiner	*Notropis stramineus*	X				
Suckermouth minnow	*Phenacobius mirabilis*	X		I, ST		
Fathead minnow	*Pimephales promelas*	X	X		Y	
Longnose dace	*Rhinichthys cataractae*	X				
Central stoneroller	*Campostoma anomalum*				Y	
River carpsucker	*Carpiodes carpio*	X	X		Y	Y
White sucker	*Catostomus commersoni*	X				
Blue sucker	*Cycleptus elongatus*	X	X	SE	U	Y
Smallmouth buffalo	*Ictiobus bubalus*	X	X			
Grey redhorse	*Moxostoma congestum*	X	X	ST	Y	Y
Black bullhead	*Ameiurus melas*	X	X	I		
Yellow bullhead	*Ameiurus natalis*			I	Y	
Blue catfish	*Ictalurus furcatus*	X				
Headwater catfish	*Ictalurus lupus*	X				
Channel catfish	*Ictalurus punctatus*	X	X	I	Y	Y
Flathead catfish	*Pylodictis olivaris*	X	X		U	U
Pecos pupfish	*Cyprinodon pecosensis*	X		ST	U	
Plains killifish	*Fundulus zebrinus*	X	X		Y	
Rainwater killifish	*Lucania parva*	X	X		Y	
Western mosquitofish	*Gambusia affinis*	X	X		Y	
Pecos Gambusia	*Gambusia nobilis*	X	X	FE, SE		
Tidewater silversides	*Menidia beryllina*	X	X	I		
Rio Grande cichlid	*Herichthys cyanoguttatum*				Y	
White bass	*Morone chrysops*	X		I		
Rock bass	*Ambloplites rupestris*	X	X	I		
Green sunfish	*Lepomis cyanellus*	X	X		Y	
Warmouth	*Lepomis gulosus*	X	X	I	N	
Bluegill	*Lepomis macrochirus*	X	X		Y	
Longear sunfish	*Lepomis megalotis*	X	X		Y	Y
Smallmouth bass	*Micropterus dolomieu*	X		I		
Spotted bass	*Micropterus punctulatus*		X	I	U	
Largemouth bass	*Micropterus salmoides*	X	X		Y	U
White crappie	*Pomoxis annularis*	X	X	I	U	
Black crappie	*Pomoxis nigromaculatus*	X		I		
Greenthroat darter	*Etheostoma lepidum*	X	X	ST	Y	
Yellow perch	*Perca flavescens*	X		I		
Bigscale logperch	*Percina macrolepida*	X		ST	N	
Walleye	*Stizostedion vitreum*	X	X	I		
White bass	*Morone chrysops*	X	X	I		

water level (Smith 2001), but may also be related to deposit feeding behavior (Vaughn and Hakenkamp 2001). Additionally, movement of tagged Texas hornshell has been documented when mussels are dislodged during flood events (Lang 2001), as has been reported for other unionids (Tucker 1996, Hastie et al. 2001). On several occasions (May- June) gravid female *P. popeii* were found lying prostrate with valves agape. This suggests that Texas hornshell may adopt reproductive strategies to increase opportunities for discharging conglutinates (masses of glochidia), similar to that suggested for other species (Amyot and Downing 1998). Epibenthic (bottom surface) movements have been observed for several individuals in the Black River, including one marked female that dislodged and moved ca. 1.5 m from a flow refuge into the open river channel (B. Lang, NMDGF, *pers.obs.*).

2.1.9 Diseases, Parasites, and Predators

Little is known about the diseases affecting unionids. Pathogenic conditions have been reported including tumor-like growths (Neves 1987), “agent X” (Bates 1987), and a bacteria (Kern 1987). Parasites on freshwater mussels include water mites, leeches, trematodes, and protozoans (Coker et al. 1921, Calnan 1976, Vidrine 1980, Howells et al. 1996). No specific disease or parasite is known for Texas hornshell.

Freshwater mussels are preyed upon by a variety of species, including mink *Mustela vison*, raccoon *Procyon lotor*, and some birds, turtles, and fish (Coker et al. 1921). The muskrat *Ondatra zibethicus* is known to prey on Texas hornshell (Lang 2001). Recent incidence of gill damage in Black River Texas hornshell has been attributed, in part, to predation by nymphs of the sulphur-tipped clubtail dragonfly *Gomphus militaris* (Levine et al. Submitted). Humans have also been a common predator of freshwater mussels, primarily for shells (button industry), pearls, and food (see Section 2.2.3 for more detail about human use of freshwater mussels).

2.1.10 Population Dynamics

Texas hornshell in New Mexico is currently limited to what is understood to be one population occupying 14-kn (9 mi) reach of the middle Black River. A capture-mark-recapture study was initiated in 1997 and continues at three sites (flow refuges) in the Black River study area (Figure 4). During a 10-year period, unmarked mussels were observed consistently in all refuges. This

Figure 4. Texas hornshell mark and recapture census and Texas hornshell marked with Floy tags, Black River, New Mexico. Photos: Brian Lang, Todd Levine.

recurrent pattern implies that mussel sub-populations in flow refuges are open to migration, which could occur via immigration from upstream sub-populations, sample variation due to epibenthic or endobenthic (within the substrate) movement of mussels within the refuges, or recruitment of smaller individuals (grow-out) into the adult population (Lang 2006).

Using the Program MARK (White and Burnham 1999) to evaluate the relative fit of statistical models to these demographic data, Berg and Levine (2006a) and Levine et al. (in prep) analyzed 13 models relating site location, river discharge, and mussel size (shell length). Survival was also allowed to vary randomly over time (i.e. each year was allowed to receive a different estimate of survival). Preliminary analyses indicated that maximum discharge over the interval between censuses affects survival and that higher riverine discharge reduces survival. This relationship is likely driven by a substantial reduction in apparent survival following high discharge and low survival observed between the 1998 and 2002 surveys - a hydrographic period of record high floods in the Black River. Analysis of the annual length frequency data indicated that size structure was similar amongst years, providing evidence of stable size-, and possibly, age-structure. These data also suggest that there is a minimum size (ca. 40 mm or 1.5 in.) at which mussels are detected by current survey methods.

2.1.11 Associated Species

Thirty-two fish species have been reported from the Black River (Cowley and Sublette 1987, Sublette et al. 1990; Table 2). Of these, longnose gar *Lepisosteus ossesus*, gizzard shad, red shiner *Cyprinella lutrensis*, fathead minnow *Pimephales promelas*, river carpsucker, blue sucker, gray redhorse, channel catfish, flathead catfish *Pylodictis olivaris*, Western mosquitofish *Gambusia affinis*, green sunfish *Lepomis cyanellus*, warmouth *L. gulosus*, bluegill *L. macrochirus*, longear sunfish, spotted bass *Micropterus punctulatus*, largemouth bass *M. salmoides*, and white crappie *Pomoxis annularis* occur in occupied range of Texas hornshell (Berg and Levine 2006b). Four of these (channel catfish, warmouth, spotted bass and white crappie) are not native to the Black River.

In the Black River, Texas hornshell are commonly found with the nonnative Asian clam *Corbicula fluminea*. Competition for food resources between native bivalves and *Corbicula* has been proposed, but there is little quantitative evidence that *Corbicula* cause changes in native mussel populations (see Strayer 1999a for a review).

2.2 HISTORICAL PERSPECTIVE

2.2.1 Habitat Trends

Draining over 49,000 km^2 (18920 sq. mi), the Pecos River originates in the Sangre de Cristo Mountains of northern New Mexico and flows south until it exits the state near Carlsbad. Gradient decreases from the headwaters to the lower Pecos River, where the channel is often wide and meandering. Water regulation drastically altered the lower Pecos River. In the 1890s, impoundment of the Pecos River began with the construction of McMillan and Avalon dams between Artesia and Carlsbad. In 1988, McMillan Dam was replaced with Brantley Dam. Discharge in the Pecos River to the Texas border is currently restricted and regulated by numerous dams (Santa Rosa, Sumner, Avalon, Upper and Lower Tansill, 6 Mile, 10 Mile, and Red Bluff). Resultantly, channel structure has been altered with areas of scour, sedimentation, and channel constriction.

In 1948, the Pecos River Compact was finalized, detailing the amount of water that New Mexico is required to deliver to Texas. Many measures utilized to meet the obligations, including holding and releasing water from reservoirs, have led to loss of suitable habitat for Texas hornshell. Habitat above dams was flooded and channel incision is common below the dams. Habitat fragmentation occurred due to loss of connecting habitats and inability of fish to move past impoundments. Additionally, manipulation of the natural hydrograph likely impacted Texas hornshell. Flow varies greatly, primarily based on irrigation needs; block releases (high volume, high velocity releases of water) and zero-flow days are common.

Unregulated groundwater pumping in the Roswell area in the early 20th century led to water table decreases, loss of springs and spring brooks, and loss of flow in the Pecos River. While Texas hornshell were not common as far north as Roswell, at least one Texas hornshell population from North Spring River (Cockerell 1902) was likely extirpated due to loss of spring flow from groundwater withdrawal from the Roswell Artesian Basin (Jones and Balleau 1996). Since the 1960s, with increased regulation, the water table has risen and surface flows in the Pecos River below Roswell have improved. However, flow has not returned to the lost springs, including North Spring River (Jones and Balleau 1996).

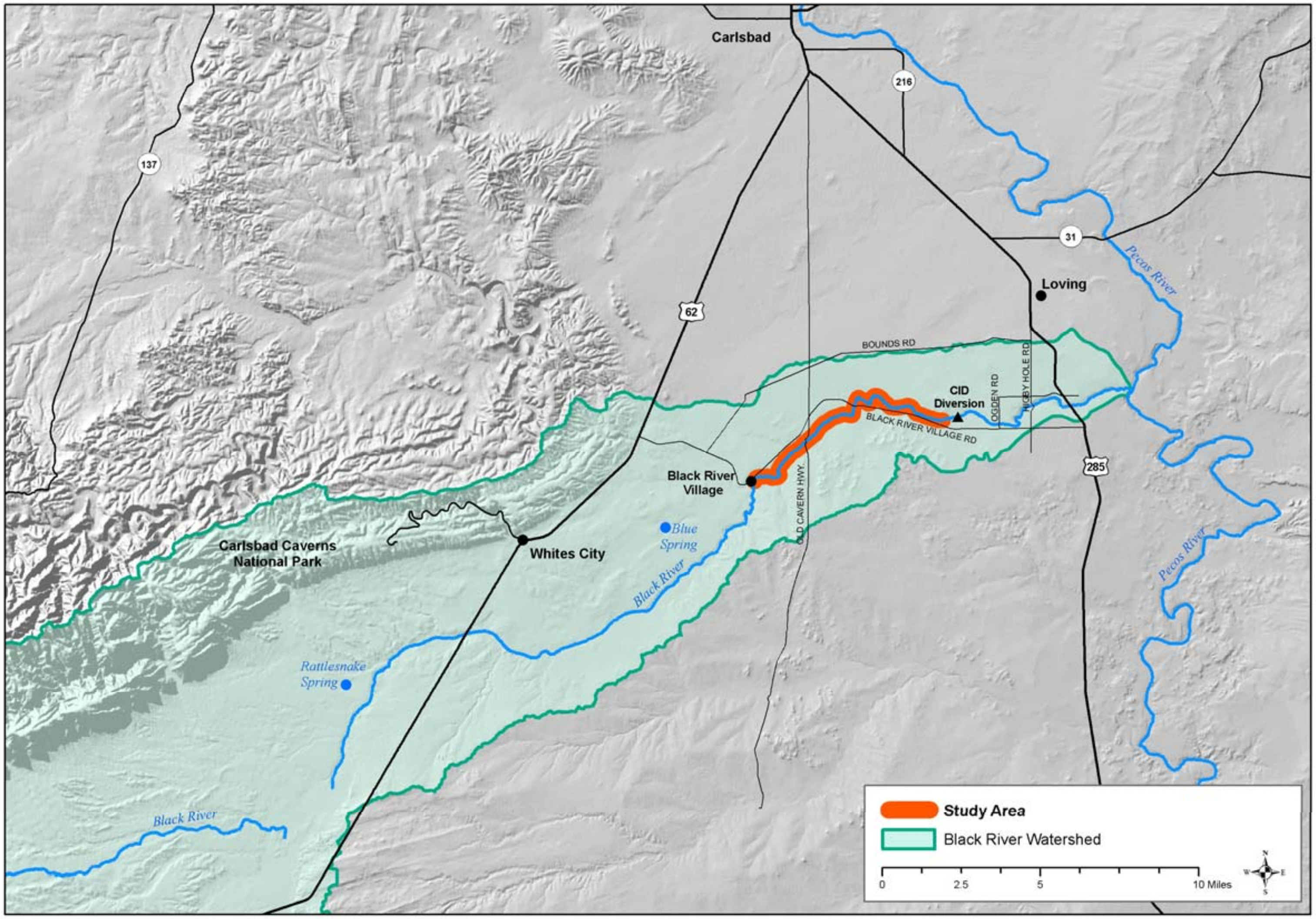
Primary land use along the Pecos River is livestock grazing and agriculture. Additionally, oil and gas operations are ongoing in the lower Pecos River watershed, primarily in Chaves and Eddy counties. Pollution from feedlots and dairy operations and extractive and refining processes can contaminate ground and surface waters in the Pecos River basin. According to the *2004-2006 State Of New Mexico Integrated Clean Water Act §303(D)/§305(B) Report*

(NMED/SWQB 2004), areas of the Pecos River in New Mexico are impaired because of sedimentation and siltation and low flow alterations, probably a result of water diversions, rangeland grazing, loss of riparian habitat, and irrigated crop production.

The Black River originates in New Mexico near the base of the Guadalupe Mountains and flows northeastwardly to join the Pecos River near Malaga, Eddy County, descending around 1000 feet over some 30 miles (Figure 6). Flow in the Black River is sustained by springs, including Rattlesnake and Blue springs, and is generally perennial in the reaches around these springs. Outside of the immediate areas below the springs, perennial flow has varied throughout the past century. For instance, in 1907, the upper perennial reach, around Rattlesnake Spring, was reported to extend 4 or 5 miles, yet in 1953, only extended 1-2 miles upstream from Rattlesnake Spring (Sullivan 1908 in Bjorklund and Motts 1959). Currently, flow is perennial for about 3.6 miles upstream of Rattlesnake Spring. An intermittent river channel extends from the latter site downstream to Blue Spring where the perennial reach of the Black River resumes flow downstream to the confluence with the Pecos River. Water from the Pecos River is added to the Black River via the CID Black River Supply Ditch at the lower end of Texas hornshell habitat.

Instream flow is affected by local precipitation, high altitude ground water recharge, local ground water table elevation, evapotranspiration, and anthropogenic water use. Surface water is removed from the system at several places, primarily for irrigation, including Rattlesnake and Blue springs and the CID Black River Canal at the CID diversion dam. Studies have shown that flows at the springs and in the river are also affected by groundwater withdrawals, particularly those from the valley fill (Bjorklund and Motts 1959). For instance, discharge from Castle Spring, which is mainly dry now, decreased historically during the pumping season and increased between irrigation seasons (Bjorklund and Motts 1959). Discharge at Blue Spring has varied over the past 100 years: in 1907, it was recorded at 15.2 cfs, with a minimum of 14.65 cfs (from Sullivan 1908 in Bjorklund and Motts 1959); from 1952 to 1956, discharge varied from 8.5 to 14 cfs, with a mean of 12 cfs (Bjorklund and Motts 1959); and from 2002 to 2006, the mean was 11.75 cfs, with a range from 6.8 to 23 cfs (USGS gage at Blue Spring above Diversion #08405450). Flow in the Black River mainstem has been recorded at the USGS gage above Malaga (#08405500) since 1947. Between 1952 and 1956, mean daily discharge ranged from

Figure 5. Black River Watershed. Watershed boundary is based on U.S.Geological Survey Hydrologic Unit Code (HUC) 1306001113, modified by NMDGF staff.



2.7 to 2500 cfs, with a mean of 15.4 cfs. From 2002 to 2006, mean daily discharge ranged from 2.6 to 912 cfs, with a mean of 10.1 cfs.

The Black River Valley has experienced repeated problems of groundwater depletion. Despite State administration of groundwater withdrawals within the Pecos River Basin (McCord et al. 2005), water levels of domestic and agricultural/range wells in the Black River area have, in the recent past, lowered and even dried-up (Black River Village residents, *pers. com.*). Lowering of the local groundwater table has been evidenced from the drying of the headspring of Castle Spring, Black River Village; the upper reaches of this spring fed system remain dry (B. K. Lang, *pers. obs*.). Currently, Texas hornshell habitat in the Black River has remained perennial. Lowest flows are typically recorded in March, at the end of the dry season when upstream water users are withdrawing their maximum allotted amounts; peak discharges occur from July through September in association with seasonal rains.

Water quality in the Black River changes from upstream to downstream due to natural (geology) and human-induced (CID Black River Supply Ditch) causes. For instance, specific conductance, a measurement of dissolved solids in water, increases downstream; from 1953 to 1955, specific conductance averaged 0.71 millisiemens (mS) at Rattlesnake Springs, 1.34 mS in Blue Spring Creek, 1.59 mS at Harkey Crossing, and 4.75 below the CID dam (Bjorklund and Motts 1959). The large increase, immediately above and below the CID dam, is attributable to the input of Pecos River water in the CID Black River Supply Ditch into the system. Increased salinity, and perhaps other changes in water quality (e.g., herbicides, insecticides) and water quantity (regulated flows) as well, below the CID dam creates unsuitable conditions for survival of Texas hornshell (Table 1; Lang 2001).

According to NMED, Blue Spring is fully supporting all designated uses throughout its length, whereas the Black River, from the headwaters downstream to the confluence with the Pecos River, is not supporting warmwater aquatic life, as indicated by ambient bioassays downstream of the CID dam (NMED/SWQB 2004). The probable source of impairment in the Black River is unknown. These water quality data, while valuable, are currently only available from areas upstream and downstream of currently occupied Texas hornshell habitat. In 2002, the U.S.

Army Corps of Engineers designated all perennial reaches of the Black River as "Critical Resources Waters" under General Condition 25 of the nationwide permits program [67 FR 2019 et seq].

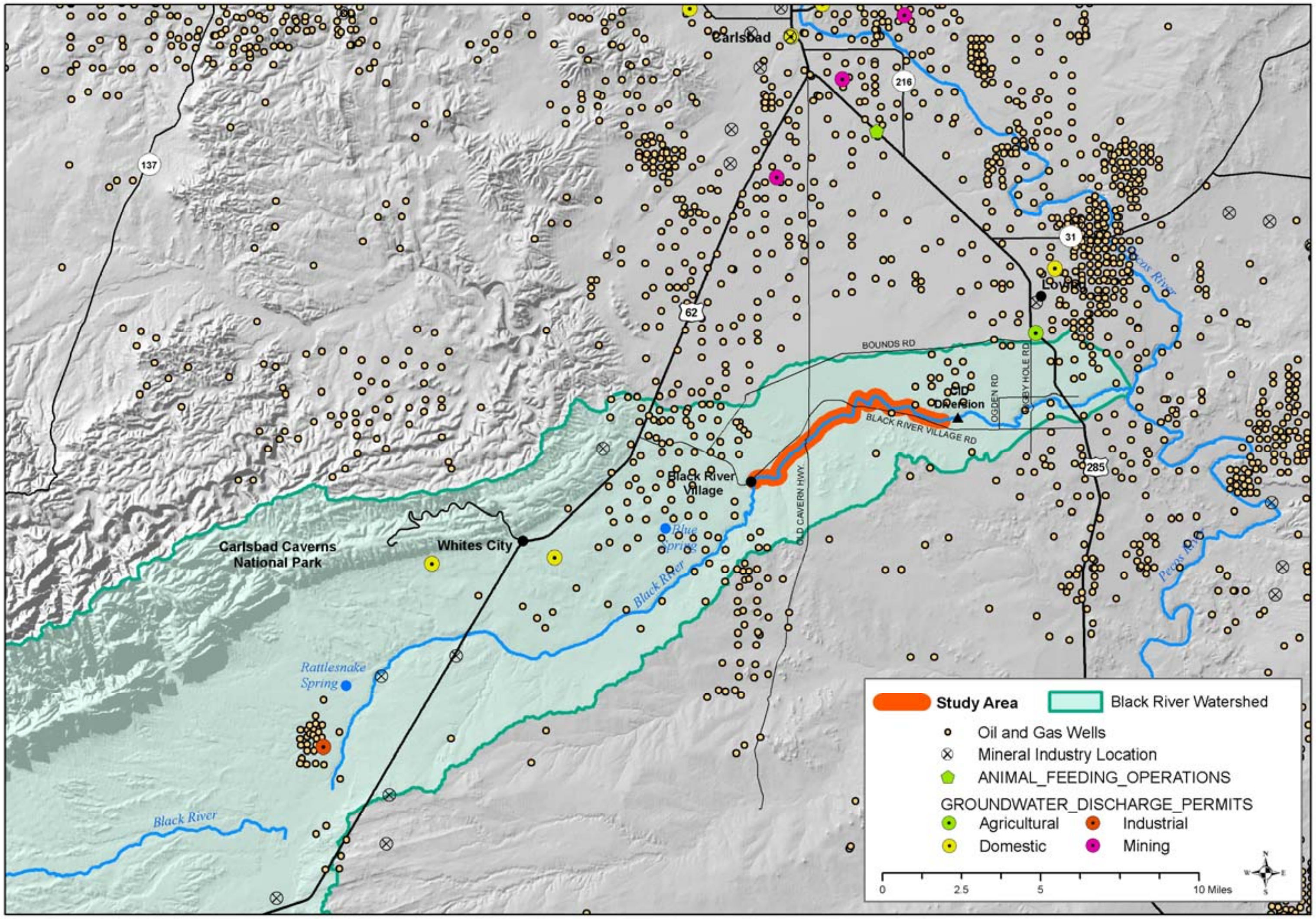
The area around the Black River is Chihuahuan Desert grassland, with land activities dominated by oil and gas extraction, livestock grazing, and agriculture. Recently, there has been an expansion of oil and gas operations in Eddy County, especially within the Black River watershed (Figure 6). Richard (1988a, 1988b) and Richard and Boehm (1989a, 1989b) documented groundwater contamination of domestic and agricultural/range wells (i.e., Washington Ranch, Ballard Wells, etc.) by petroleum-derived hydrocarbons and sulfides in upper Black River Valley. Richard and Boehm (1989b) reported "severe" sulfide contamination of Blue Spring (1988), a regionally significant artesian spring that is a primary hydrologic source for the Black River (the most down-gradient surface discharge point of groundwater in the upper Black River Valley. These authors indicated that gas contamination originating up-gradient might have been transported down-gradient (ca. 20 miles) to Blue Spring. Such long-distance transport of groundwater is common in karst, evaporite rock (White et al. 1995, Martinez et al. 1998), and raises concerns for surface water quality of the Black River, especially considering the concentration and proliferation of petroleum industry operations throughout the Black River drainage.

Recent investigations have only found Texas hornshell in the middle Black River from Black River Village downstream to the CID diversion. Restriction to this area may be due to the inability of host fish to pass the Black River Village dam upstream. Downstream, increased salinity likely prevents habitation by Texas hornshell.

2.2.2 Population Trends

The Black River population of Texas hornshell is the only extant population currently known in New Mexico. Since 1997, NMDGF has tracked the status of Texas hornshell at four sites (refuges) in the Black River. Currently, three of the four refuges continue to demonstrate colonization, either through movement of mussels into the area from upstream sources, recruitment, or sample variation. Within the refuges, a variety of sizes/ages are present and the

Figure 6. Land use activities in the Black River Watershed. Oil and gas activity information is from the Bureau of Land Management, New Mexico Office 2006, and includes abandoned, active, dry, not drilled, shut in, status unknown, and temporarily abandoned gas, injection, oil, and multiple use wells.. Mineral industry locations are from Earth Data Analysis Center UNM, 1994. Animal feeding operation and groundwater discharge permit locations are from New Mexico Environment Department, 2007



population appears viable (Lang 2001). The stability of several suitable host fish species populations and Texas hornshell affinity for and utilization of flow refuges appears to favor the persistence of Texas hornshell in the middle Black River.

At one refuge, the mussel sub-population steadily declined (no recolonization, low survival and recapture rates) and since 2002 no mussels have been recovered there (Lang 2004). This decline was attributed to impoverished habitat conditions (channel scouring, sediment loading) resulting from frequent large-volume flood events in 2000.

A single extant population occurs in the lower Rio Grande near Laredo, Webb County, Texas (Strenth et al. 2004), and relic populations may exist elsewhere in the Rio Grande system, as recently dead shells have been found downstream of Big Bend National Park (Howells and Ansley 1999, USFWS 2005). Recent reports of shells from the Rio Conchos, Llano River, and South Concho River in Texas have not been verified (Howells 2001). In Mexico, Texas hornshell have been reported from the rios Salada, Panuco, and Valles, but the validity of these reports and the persistence of current populations are unknown (USFWS 2005).

2.2.3 Use and Demand Trends

Freshwater mussels were an important natural resource for Native Americans who used the shells for tools, jewelry, trade, and food (Kunz 1897, Neck 1982, Howells et al. 1996). European settlers also utilized freshwater mussels primarily for buttons from the mid-1800s until the mid-1900s. In many areas, over-harvest led to depletion of mussel beds. Currently, the primary commercial use of freshwater mussel shells is to "seed" other mollusks for the production of pearls. Texas hornshell has never been commercially utilized and because of its endangered status in New Mexico, it is illegal to collect the live animal or spent shell without permit authorization from NMDGF.

2.2.4 Past Management

Texas hornshell was listed under the Wildlife Conservation Act (WCA) as Endangered in New Mexico in 1983 [19.33.6.8 NMSA 1983]. Protection under the WCA is limited to take (harass, hunt, capture or kill any wildlife or attempt to do so); there is no critical habitat designation or regulatory protection of occupied or potential habitats. Texas hornshell is considered a Species of Greatest Conservation Need in the New Mexico Comprehensive Wildlife Conservation Strategy (NMDGF 2006).

This mussel is not currently recognized as endangered in Texas. A state fishing license, commercial mussel harvest license, shell buyers license, or scientific collection permit is required for mussel collection in Texas. However, because the minimum harvest size of mussels is 2.5 inches shell height, which few Texas hornshell meet, and since this species is uncommon in Texas, collection for personal or commercial use is unlikely. The American Fisheries Society, a national association of fishery professionals, recognizes Texas hornshell as endangered (Williams et al. 1993).

Currently, Texas hornshell is considered Candidate Species under the Federal Endangered Species Act, "one for which [USFWS] has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened but for which preparation and publication of a proposal is precluded by higher-priority listing actions"(USFWS 2005, 71 FR 53756 53835). Although USFWS encourages conservation of these species, candidate species receive no statutory protection under the ESA. Currently, Texas hornshell has a priority number of 2, which is the highest ranking assigned to a species (USFWS 2005, 71 FR 53756 53835). On 11 May 2004, USFWS was petitioned to list Texas hornshell along with 224 other species on the Candidate list as a Federally Endangered Species with Critical Habitat, but no action has been taken [70 FR 24869-24934].

The New Mexico Department of Game and Fish has been working with Texas hornshell in New Mexico extensively over the past 11 years (see Lang 2001 through 2006 for a review). Surveys of historic habitat in New Mexico and Texas were completed in cooperation with Texas Parks and Wildlife Department (Lang 2001, Strenth et al. 2004). Mark and recapture studies began in 1997 to document population changes in occupied habitat in New Mexico (Lang 2001, 2005, 2006, Berg and Levine 2006a; Figures 5 and 6). Several field studies investigating reproductive biology (Smith et al. 2003), population demographics, and habitat affinities have been completed or are ongoing (Lang 2001, 2005, 2006, Berg and Levine 2006a, b). Additionally, laboratory studies have been undertaken to determine salinity tolerances and glochidia-host relations with the Albuquerque BioPark, Dexter National Fish hatchery, and Miami University (Lang 2001, Lang 2004, Berg and Levin 2006b, Gordon et al. In Review). Preliminary genetic analyses were completed with Kent State University (Hoeh et al. 1999).

2.3 HABITAT ASSESMENT

2.3.1 Current Status

Despite intensive efforts to locate additional populations of Texas hornshell in the Pecos, Delaware, and Black rivers in New Mexico, the only occupied habitat exists in 14 km (8.7 miles) of the middle Black River (Lang 2001). Although Texas hornshell appears restricted between two low-head dams, habitat within this reach of the Black River is of sufficient quality to support persistence of the species. The presence and utilization of flow refuges allows Texas hornshell to survive high flows. Persistence of minimal base flow of good water quality in the Black River, as supported by the groundwater aquifer and precipitation, provides sufficient habitat for Texas hornshell to survive past drought conditions (Lang 2001).

Historic and recent land-use practices in this reach have generally favored persistence of the species. Current activities occurring within the watershed include: agriculture, cattle grazing, and oil and gas development. Water use, both from surface diversions at Rattlesnake and Blue springs and groundwater pumping for domestic and commercial uses, also occurs upstream of and throughout Texas hornshell habitat. While these land-use activities may not appear as imminent threats to short-term persistence of Texas hornshell, the potential for increased resource consumption is real and the gradual accumulation of such enigmatic, piecemeal impacts can manifest irrevocable degradation within the Black River in the long-term.

2.3.2 Projections

An increase in intensity of land uses (summarized above) within the Black River watershed may threaten Texas hornshell habitat. Of particular concern is loss of sufficient water quality and quantity necessary for survival of the species. Groundwater depletion and ground- and surface-water contaminants are considered principal causes of decline in unionid mussels (Metcalf 1982, Taylor 1985, Williams et al. 1993, Neves et al. 1997, Strayer 1999).

Within occupied habitat, there are several river crossings in need of repair and maintenance (Figure 7). These crossings pose concerns for catastrophic traffic accidents due to commercial transport of chemical products (e.g., produced brine water, raw and refined petroleum products, herbicides, pesticides, toxic chemicals) across the Black River. An accidental spill of contaminates would pollute surface waters of the river and threaten extant populations of the Texas hornshell.

Figure 7. Low water crossing on the Black River, Eddy County, New Mexico. Photo: Julie McIntyr.

Surface water pollution from other sources is also a concern. In 2002, the Black River was contaminated with tebuthiuron, a common herbicide. Shortly after application in upland areas, heavy rains washed the herbicide into Threemile Draw, a tributary to the Black River. Farmers downstream in Malaga reported damage to irrigated crops from this contaminate. Although tebuthiuron is slightly toxic to aquatic invertebrates (Camilleri et al. 2003), no adverse effects on the mussel population were found (Lang 2004). Unioinids are known to be relatively insensitive to some pesticides and organic compounds (Newton 2003).

Toxins from the golden algae *Prymnesium parvum* potentially threaten Texas hornshell. Large-scale fish kills attributed to toxins produced by this alga have occurred in the Pecos River in New Mexico and Texas, most recently (2002 through 2005) from Brantley Reservoir downstream into Texas (Rhodes and Hubbs 1992, Watson 2001, Denny 2006). These toxins are highly poisonous to gill-breathing aquatic organisms, including mollusks (Paster 1973). To date, no fish kills have occurred in the Black River where Texas hornshell occurs, but the proximity of previous blooms (i.e., Pecos River at Black River confluence) is a concern. Die-offs of co-habitating organisms, from golden algae or other causes, may also threaten the water quality necessary for Texas hornshell. In particular, the Asian clam *Corbicula* is prone to rapid die-offs, which can cause ammonia generation, reduce dissolved oxygen, and effectively kill native mussels (McMahon and Williams 1986, Strayer 1999a).

Re-occurrence of subsurface petroleum contamination of the Black River, as reported by Richard (1988a,b) and Richard and Boehm (1989a,b), is also of concern. Rates and directions of subsurface transport of groundwater need to be determined so that appropriate monitoring may be implemented to insure protection of the Black River from up-gradient groundwater contamination. Additionally, impacts from oil and gas development operations on movement of groundwater should also be investigated. Long distance transport of groundwater is common in karst evaporite rock (White et al. 1995, Martinez et al. 1998), raising concern for contamination of groundwater source zones and surface water of the Black River, especially considering the proliferation and concentration of petroleum industry operations through the watershed.

Decrease in water quantity is also a concern. Although perennial springs of the Black River have been sufficient to ensure surface flow in occupied habitat, several instances exist in the Pecos River watershed, particularly near Roswell, where groundwater pumping has led to decreased surface water flow (Fiedler and Nye 1933, Thomas 1959, Havenor 1968, Jones and Balleau 1996). In the Black River watershed, flows of springs and the river are related to precipitation and water use (Bjorklund and Motts 1959). Studies have shown that flows at the springs and in the river are affected by groundwater withdrawals; discharge from these systems decreases during the pumping season (Bjorklund and Motts 1959).

Water use, both surface and ground, is permitted by the New Mexico Office of the State Engineer (State Engineer or OSE). Under New Mexico law, the oldest water rights have priority, and if water is not used beneficially, the right can be lost. Based on flows recorded in recent years (2000-2006) at Blue Springs and in the Black River above the CID diversion, more surface water is appropriated than is available in the system (R. Turner, OSE, *pers.comm.*, April 2007). However, because of physical limitations on how much can actually be used beneficially by the right holders, not all that is appropriated is being used. Additionally, the right of the Carlsbad Irrigation District to withdrawal water at the CID Black River Canal is senior to some upstream rights and therefore, during much of the year, upstream surface water users are required to send water downstream, through Texas hornshell habitat, to CID. Under current appropriations, the most likely time for surface water to cease in Texas hornshell habitat is from January through March.

Currently, the Black River system is considered fully appropriated, meaning that no additional water is available for development. However, under New Mexico law, new domestic wells are permitted up to 1-acre foot per year [72-12-1.1 NMSA 1978]. Temporary wells are also permitted if they will not take more than a 0.1 acre-foot per year from surface flow of the Black River. Other water uses are reviewed by the State Engineer to determine water availability and if use will impair existing rights, public welfare, and water conservation. The State Engineer can place conditions on the use to limit impairment. Additionally, when a water right holder wishes to alter the use of his water, the application is reviewed to insure that no net loss occurs from the system. Conditions are enforced through quarterly meter readings, and monetary fines and payback policies can be required for over-use (T. Williams, Office of the State Engineer, *pers.comm.*, April 2007).

The Interstate Stream Commission (ISC) is responsible for meeting New Mexico's water obligations to neighboring states, including compliance with the Pecos River Compact, New Mexico's agreement with Texas concerning Pecos River water. Since 1988, New Mexico has struggled to meet its obligations and has been trying to bank water for compliance. As the Black River contributes directly to New Mexico's delivery of water to Texas, ISC reviews water use applications presented to the State Engineer to insure the delivery of water to Texas is not impaired by the new use (E. Sawyer, ISC, *pers.comm.*, March 2007).

Oversight of water of the Black River by both the ISC and State Engineer under existing regulations and circumstances should help assure that instream flows in Texas hornshell habitat are maintained. However, additional approaches that encourage instream flow, such as recognition of fish and wildlife as a beneficial use, are yet to be tried in the system. No guarantee exists that currently occupied Texas hornshell habitat will remain perennial. Extended drought could negatively impact Texas hornshell habitat. In addition to decreased ground and surface water availability, long-term drought can lower the water table, affecting the flow of ground water and chemistry of surface flow (Dahm et al. 2003). The most severe drought recorded in New Mexico occurred between 1950 and 1956. Based on the discharges reported in the Black River from 1952 to 1956 (daily mean of 15.4 cfs) compared to recent discharges (2002 to 2006, daily mean of 10.1 cfs), flows in the Black River are currently lower than during the drought of the 1950s. Future drought may stress an already over-appropriated system, likely leading to dewatering of habitat.

Climate change due to global warming is expected to exacerbate existing threats to Texas hornshell. Based on current understanding, air temperatures are expected to rise and precipitation patterns will change (for a summary of global warming effects in New Mexico, see *Potential Effects of Climate Change on New Mexico,* Agency Technical Workgroup, State of New Mexico, http://www.nmclimatechange.us/). For spring-fed systems like the Black River, this could lead to warming of surface flow (Covich et. al. 1997). Texas hornshell may be particularly impacted by rising temperatures, as upstream movement to cooler waters may be hampered by the inability of host-fish to pass in-stream barriers. Reductions in streamflow, particularly late in summer, are also expected (Poff et al. 2002). Changes in precipitation leading to more severe flooding and drought may lead to physical habitat alterations, such as channelization and sedimentation, and chemical changes in the water, such as decreased dissolved oxygen (Covich et al. 2003). Such changes in water quality and quantity may be detrimental to Texas hornshell in the Black River and could lead to their extirpation.

Alterations to the physical habitat of Texas hornshell are also of concern. Construction of additional impoundments or modification of the existing low-head dams on the Black River could impact habitat as well as distribution and reproduction of Texas hornshell by impeding movement of host fish. In 2002, the U.S. Army Corps of Engineers designated all perennial reaches of the Black River as "Critical Resources Waters" under General Condition 25 of the nationwide permits program [67 FR 2019 et seq]. This designation allows the Army Corps of Engineers discretionary authority to modify nationwide permits for regional conditions, which here include critical invertebrate habitat.

Over the long-term, land use practices that result in excessive clearing of vegetation can result in increased erosion and sedimentation, increased arroyo entrenchment, and changes in stream channel morphology and substrate composition (Wood and Armitage 1997). These environmental perturbations, if left unabated, can adversely affect aquatic ecosystem health and integrity, long-term viability of mussel populations, and habitat suitability of flow refuges colonized by Texas hornshell (Lang 2001). Several programs exist through the Natural Resources Conservation Service and Carlsbad Soil and Water Conservation District to assist landowners with management of upland and riparian areas.

Very little suitable habitat exists for Texas hornshell in New Mexico outside of the occupied reach in the Black River (Lang 2004). Areas upstream of currently occupied habitat, above the Black River Village Dam, may be of sufficient quality for Texas hornshell. Extensive rehabilitation, including measures such as restoring a natural hydrograph, channel renovation, and re-establishing riparian function, will be necessary to provide suitable habitat elsewhere within the historic range of Texas hornshell.

Land ownership of currently occupied habitat is private, primarily large family ranches. Generations of the same families have cared for these ranches in such a way that the Black River remains the last stronghold for the species. However, like many areas of the west, these large tracts may be subject to subdivision and development, as traditional land uses, like ranching, are forgone. Changes in land use that may occur following subdivision and development are difficult to predict, but should be acknowledged as a potential threat to habitat. Several programs, such as ranch conservation easements, may be useful in protecting both the heritage of the Black River community and Texas hornshell.

2.4 POPULATION ASSESSMENT

2.4.1 Current Populations

The Texas hornshell population in the middle Black River is currently viable with mixed age-classes and indications of active recruitment of juvenile mussels into the breeding population (Lang 2005). Although a variety of host fishes have been identified in the laboratory (Gordon et al. In review), field studies indicate that this pool of potential hosts (26 species) may be limited to fewer species (Berg and Levine 2006a). Even so, the abundance of suitable host fishes in the Black River, such as gizzard shad and gray redhorse, indicates that host availability may not be a population-limiting factor.

Although live *P. popeii* occur in Texas (Strenth et al. 2004), a reproducing population is only known from the Black River. This makes the status of Texas hornshell in New Mexico of even greater importance. Information concerning the demographic connectivity of mussels in the middle Black River in currently unknown and merits study. Investigations to determine the distribution and abundance of Texas hornshell in Texas and Mexico are vital to conservation of the species.

In New Mexico, Texas hornshell is currently restricted by availability of suitable habitat. Although the Black River population appears stable, there is little opportunity for populations to expand without the installation of fish passages (or habitat renovation by removal of barriers [dams]) and habitat restoration.

2.4.2 Projections

Removal of host-fish, such as through large fish kills associated with golden algae blooms, disease or habitat modification, could negatively impact viability of Texas hornshell in the Black River. Changes in habitat connectivity, such as insertion or removal of dams and river crossings, may alter functionality of host-fish and distribution of Texas hornshell populations.

Introduction of nonnative mollusks, such as the New Zealand mudsnail *Potamopyrgus antipodarum* and zebra and quagga mussels, *Dreissena polymorpha* and *D. bugensis* respectively, could negatively impact *P. popeii*. These nonnative mussels threaten freshwater mussel populations throughout North America primarily by epizootic colonization (Figure 8), which restricts valve operation, causes shell deformity, and smothers siphons, resulting in death by starvation and asphyxiation (Williams et al. 1993, Schloesser *et al.* 1996, Baker and Hornbach 1997, Neves et al. 1997, Strayer 1999a). These species have been established in the eastern United States for over two decades and many efforts are underway to slow and stop their spread into the west. In early 2007, quagga mussels were confirmed west of the 100th Meridian, in the Colorado River in Lakes Mead, Havasu, and Mohave (for updated distribution, see http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/). *Dreissena* mussels are most commonly spread by boat traffic, which while making their direct introduction into the Black River unlikely, makes establishment into nearby waters, such as the reservoirs of the Pecos River, probable, where they can be spread further through bait buckets and recreational equipment.

Although *Corbicula* are very abundant in the Black River, there is little quantitative evidence of competition between native mussels and *Corbicula* for food and space resources (Strayer 1999a). Negative impacts on Texas hornshell because of decreasing dissolved oxygen and rising ammonia levels following a *Corbicula* die-off is a more likely threat (Strayer 1999a).

Figure 8. Epizootic colonization of freshwater mussel by nonnative zebra mussel. Photo: Kurt Stepnitz

2.5 ECONOMIC IMPACTS

Eddy County, New Mexico, where occupied Texas hornshell habitat occurs, has a human population of approximately 51,688, up 0.06% from 2000, with a median age of 36.4 years (2004 Census). Urban centers in the area include Carlsbad and Artesia. Average annual salary is $30,317 (2004 Census) and unemployment is approximately 4.7% (October 2005, New Mexico Department of Labor). Approximately 17% of the labor force was employed in public administration (federal, state, or local) and top private industries in the county are mining (13% of total employed persons), health care and social service (12%), and retail trade (10%) (2004 Annual Average, New Mexico Department of Labor). There are 510 farms in the county, primarily cattle operations (2002, New Mexico Department of Agriculture). Among New Mexico counties, Eddy County is the second largest oil producer (18,767,063 barrels in 2005) and third largest gas producer (238,111,400 thousand cubic feet in 2005) (January 2006, New Mexico Oil Conservation Division).

2.5.1 Positive Impacts

Recognition of the economic benefits of conserving and restoring a healthy environment is increasing in the United States (ECONorthwest 2002). This view is influenced by costs of cleaning-up environmental problems, the recognized value of basic ecosystem services (e.g., clean water and air), and growth in the service and recreation industries. Currently, although it is evident that the public values nature and is willing to place dollar amounts on conservation through taxes, legislation, and other means, it is difficult to determine the exact economic value of conserving particular natural resources. By evaluating use and non-use values of environmental assets, total economic value of conservation activities, such as recovery of Texas hornshell, can be estimated. Use values include both Direct Use Value, such as recreation activities, and Indirect Use Value, such as ecological function of a system. Non-use values include Option Value, ability to have this resource in the future, Bequest Value, value of passing on the resource, and Existence Value, value of knowing the resource exists (Munasinghe 1992, Bulte and Van Kooten 2000, Hughey et al. 2003).

Some Direct Use Values are available for New Mexico. In 2001, residents and non-residents spent about $1 billion on wildlife-associated recreation, including fishing, hunting, and wildlife-watching activities in New Mexico (USFWS 2003). Additionally, studies are available that estimate the Willingness To Pay (WTP) of households for the conservation of natural resources, such as instream flow and endangered species. Using the Contingent Valuation Method, a hypothetical market is made which allows the public to place a monetary value on the preservation of natural resources (Mitchell and Carson 1989). For example, a survey was sent to households in the affected area and throughout the U.S. to determine the WTP value for conserving nine fish species in six rivers in the Four Corners region by improving habitat (Loomis 1998). The mean WTP was estimated to be $265 per household per year. Other studies focusing on individual species, found lower WTP values of $29/household/year for Rio Grande silvery minnow *Hybognathus amarus* (Barrens et al. 1996) and $8/household/year for Colorado pikeminnow *Ptychocheilus lucius* (Cummings et al. 1994; see Loomis and White 1996 for a review). Looking at a variety of species and studies, Loomis and White (1996) found that WTP varies with projected species population changes, the visitation rate of the household to the area, and the frequency of payment. No specific studies have been completed on public valuation of

Texas hornshell, but it is clear from studies on other aquatic species and habitats, that the public does place monetary value on conservation of species.

In addition to direct economic benefits, there are also secondary economic benefits to Texas hornshell recovery. Habitat improvement projects, such as cost-share incentive programs, may decrease many negative effects that resulted from degradation of the watershed in the past, including loss and contamination of ground and surface water. Indirect effects of habitat conservation and watershed restoration may include reduced erosion and increased native grassland vegetation. These changes will lead to more forage and better range for livestock, while protecting Texas hornshell habitat.

Working cooperatively with federal, state, local, and non-profit agencies and private individuals also has positive economic value. In addition to avoiding duplicative efforts and funding, cooperation now can avoid increased restrictions in the future. Texas hornshell recovery efforts will work toward accomplishing the goals of the New Mexico Comprehensive Wildlife Conservation Strategy, a priority for state agencies (NMDGF 2006). Through combining efforts to restore native species and associated habitats in the watershed, more work can be accomplished and future litigation and restitution activities may be avoided. Texas hornshell is currently a candidate for federal listing under the Endangered Species Act (ESA). Through collaborative efforts to recover the species and its habitat, federal listing and possible subsequent regulatory restrictions might be avoided. Recovery of Texas hornshell also may contribute to conservation of the native warmwater fishery of the Black River and conservation of other imperiled and rare species in the area, including blue sucker, grey redhorse, Pecos gambusia *Gambusia nobilis*, greenthroat darter *Etheostoma lepidum*, plainbelly watersnake *Nerodia erythrogaster transversa*, Western river cooter *Pseudemys gorzugi*, and yellow-billed cuckoo *Coccyzus americanus*.

2.5.2 Negative Impacts

<u>Recovery actions under the WCA and this Plan are voluntary and will affect only those entities willing to implement recovery actions.</u> Therefore, direct economic effects cannot be predicted precisely. Protection and conservation of Texas hornshell requires preservation and

enhancement of the extant population and potential restoration of historic populations and habitats. These actions may require modifications of oil-gas field operations, livestock grazing, and water withdrawal and distribution practices. Reductions in or procedural alterations (such as implementing Best Management Practices) of these activities to benefit Texas hornshell may have short-term negative economic impacts. In the long-term, less expenditure may be needed to rectify adverse environmental consequences that could result from these activities, and therefore, there could be an economic benefit derived from recovery efforts (ECONorthwest 2002). Residential and commercial development, as well as the infrastructure needed to support such growth, such as road improvement and water development, also may have negative impacts on the species. Completion of these activities using methods that minimize impacts on Texas hornshell habitat may incur additional costs, but again, the long-term economic benefits of environmental planning are recognized (ECONorthwest 2002). Inclusion of multiple resource users and land managers into the recovery process is intended to mitigate these effects.

2.6 SPECIAL CONSIDERATIONS

2.6.1 Federal Jurisdiction and PECE Policy

Currently, Texas hornshell is federally treated as a candidate species, indicating that it may warrant future listing under the ESA. Candidate species receive no statutory protection under the ESA, although the USFWS encourages conservation of these species to avoid future protection under the ESA. One of the benefits of this Plan is to work towards recovery and conservation of the species on a local level, which may prevent federal listing. If listing occurs, USFWS will have jurisdiction over protection of the species.

Although the impetus and direction for this recovery plan originates from New Mexico state laws and regulation, and not proposed federal listing, NMDGF is taking into consideration the federal Policy for Evaluation of Conservation Efforts (PECE) guidelines during the development of this Plan [68 FR 15100]. This policy outlines the standards USFWS will use to evaluate effects that current or planned conservation efforts may have on listing decisions, while also providing guidance to other agencies and stakeholders in development of agreements or plans that may preclude federal listing.

2.6.2 Comprehensive Wildlife Conservation Strategy

New Mexico Department of Game and Fish recently completed the Comprehensive Wildlife Conservation Strategy (CWCS) in fulfillment of federal requirements to receive State Wildlife Grant (SWG) funding (NMDGF 2006). One purpose of SWG funding and CWCS is to promote conservation actions before federal listing is necessary; CWCS will guide conservation efforts to be more strategic, holistic and pro-active. The New Mexico Department of Game and Fish identified Species of the Greatest Conservation Need for New Mexico, including Texas hornshell. This recovery plan will help to implement the strategies identified in the CWCS for Texas hornshell and the lower Pecos River basin.

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3 MANAGEMENT STRATEGY

Section 3 contains the management goal and objective of Texas hornshell recovery. This section also details the problems and opportunities affecting attainment of the stated objective and the broad strategies that will be employed to surmount these issues and reach the objective.

3.1 Management Goal and Objective

Goal: Self-sustaining populations and habitats of Texas hornshell are restored and conserved in New Mexico.

Objective: That by 2030, populations of Texas hornshell in New Mexico are of sufficient size and security to ensure survival in the state.

Objective Parameters

- The current population and habitat of Texas hornshell is secure and self-sustaining
- At least one additional self-sustaining population in historic habitat exists such that loss of the middle Black River population will not result in extirpation of the species in New Mexico
- Measures are in place to insure that Texas hornshell populations and habitats are guarded against human-induced loss.

3.2 Management Issues and Strategies

Issue 1. Limited Populations Texas hornshell is currently restricted to approximately 14 kilometers in the Black River and surveys indicate that suitable habitat is rare within the historic range of this species in New Mexico. The extremely limited distribution, specific habitat needs, and narrow life history requirements render the Texas hornshell susceptible to extinction in New Mexico.

Strategy 1. Monitor the extant population of Texas hornshell in the Black River, including the mark-recapture study, to document status and determine whether the middle Black River contains one or more populations.

Strategy 2. Establish infrastructure for captive rearing and holding of juvenile and adult mussels.

Strategy 3. Develop procedures to mitigate for loss of mussel populations and/or habitat in the event of an unforeseen, catastrophic event.

Strategy 4. Determine the biology of juvenile Texas hornshell, including habitat requirements and recruitment.

Strategy 5. Assess the genetic variability and viability of Texas hornshell populations in the Black River.

Strategy 6. Determine the biological needs of host fishes and population sizes necessary to support Texas hornshell reproduction and population viability of host species.

Strategy 7. Secure populations of host fishes throughout historic habitat.

Strategy 8. Remove or improve barriers to host fishes movement within the Black River and among the Black River and populations located in other rivers to increase the dispersal of infected hosts.

Strategy 9. Identify suitable, secure habitats within unoccupied reaches of the Black River and other historic habitats for establishing additional Texas hornshell populations.

Strategy 10. Encourage surveys for additional populations of Texas hornshell in Texas and Mexico.

Issue 2. Habitat Limitations Human-caused habitat modifications (e.g., riverine impoundment, low-head dams, regulated flows, ground- and surface- water withdrawals, water delivery systems, channel incision and sedimentation, and impoverished water quality) have severely reduced the amount of habitat available for Texas hornshell in New Mexico. Additional habitat is necessary for recovery of Texas hornshell.

Strategy 1. Increase government agency and public understanding and support for federal, state, local and private programs that will promote and enhance ecosystem integrity of the Black River and it's watershed for the benefit of the Texas hornshell, other aquatic and aquatic-dependent resources, and land uses.

Strategy 2. Work with the New Mexico Environment Department and other experts to determine and implement the appropriate ground and surface water quality parameters and frequency for monitoring in the Black River to insure Texas hornshell survival, including monitoring of fish and invertebrate tissue for contaminants.

Strategy 3. Assess the feasibility of nominating waters of the Black River as an Outstanding National Resource Water under the authority of the Clean Water Act (see Appendix II for more information on this program). If feasible, work with the New Mexico Environment Department and other stakeholders on the nomination.

Strategy 4. Work with the Lower Pecos River Watershed Alliance and other local groups to include the Black River as a priority in regional watershed protection plans and activities.

Strategy 5. Develop procedures to mitigate for loss of mussel populations and/or habitat in the event of an unforeseen, catastrophic event.

Strategy 6. Work with the New Mexico Office of the State Engineer to determine and implement methods to insure continued adequate water flow for Texas hornshell in the Black River.

Strategy 7. Identify and secure resources to promote habitat restoration and protection under federal, state, and local programs.

Strategy 8. Assess the effects of oil and gas operations and groundwater mining on groundwater quality and quantity in the Black River basin.

Strategy 9. Identify and implement appropriate "Best Management Practices" and permitting stipulations for activities in the Black River watershed.

Strategy 10. Work with land management agencies and landowners to determine the best means of restoring and enhancing rangeland and riparian areas to preserve water quality and quantity of the Black River and assist with the implementation of such practices.

Strategy 11. Identify and rehabilitate historic habitats where feasible and secure their protection. Where possible, work with private landowners and land management agencies to remove existing impediments to natural range expansion of Texas hornshell.

Strategy 12. Coordinate efforts within existing projects and current land uses to enable habitat restoration and protection of riparian and upland areas.

Strategy 13. Increase enforcement of laws regulating illegal activities along the Black River, including trespass squatting, fishing, and dumping.

Issue 3. Aquatic Nuisance Species Aquatic Nuisance Species (ANS) such as zebra and quagga mussels, New Zealand mudsnail, non-native crayfish and golden algae, if introduced into the Black River, pose significant threats to the continued existence of Texas hornshell and host fishes.

Strategy 1. Develop procedures to respond to the introduction of aquatic nuisance species in the Black River to mitigate for loss of mussel populations and/or habitat.

Strategy 2. Participate in state and regional strategies (e.g., Western Zebra Mussel Task Force, 100th Meridian Initiative) to prevent the introduction of ANS in New Mexico.

Strategy 3. Adopt the Draft New Mexico State Aquatic Nuisance Species Management Plan as a guidance document with strategies to prevent the introduction of ANS in the Black River and lower Pecos River.

Strategy 4. Develop and disseminate guidelines for the Black and Pecos rivers that provide information on methods to prevent the introduction and spread of ANS, including updating and enforcing NMDGF regulations in the lower Pecos River basin.

Strategy 5. Encourage public outreach programs which will assist in the prevention and early detection of ANS introduction.

Issue 4. Land Management Texas hornshell occurs solely on private lands along the Black River, which are surrounded by public lands, primarily administered by Bureau of Land Management (BLM) and State Lands Office (SLO). While past land-use practices throughout the middle reach of Black River have generally favored the persistence of a relict population of Texas hornshell, no formal agreements exist for continuance of similar or alternative land-use practices basinwide. Texas hornshell habitat needs to be secured by encouraging sound ecological stewardship of the Black River watershed by private landowners, land management agencies, the oil and gas industry, and government agencies charged with managing resources in the area.

Strategy 1. Encourage participation of private landowners in Candidate Conservation Agreements with Assurances (USFWS) (see Appendix II for more information on this program).

Strategy 2. Assist private landowners in securing incentive funds for watershed and rangeland restoration projects to improve habitat for the Texas hornshell under, but not limited to, the following programs:

EQIP and WHIP (Natural Resource Conservation Service [NRCS])
Water Trust Board Grants (Carlsbad Soil and Water Conservation District)
319 (New Mexico Environment Department)
Landowner Incentive Programs (NMDGF)
Partners for Fish and Wildlife (USFWS)
Private Land Stewardship Programs (NMDGF/USFWS)
Grazing Lands Reserve Program (NRCS)

Strategy 3. Engage local, state, federal agencies, private landowners, and the oil and gas industry to promote transportation safety and protect aquatic dependent life of the Black River by improving existing river crossings or by considering alternative transportation routes for heavy truck traffic.

Strategy 4. Create a recovery implementation team to coordinate and guide conservation efforts.

Issue 5. Needed Research Critical biological information is lacking for the Texas hornshell, which can lead to speculative management and unsupportable goals.

Strategy 1. Support research focusing on, but not limited to: basic life history, reproductive biology, feeding and nutrition, habitat use by juvenile and adult mussels, impacts on biology by changes in water quality and quantity, population genetics, and population viability analysis.

Strategy 2. Working with the New Mexico Environment Department to determine baseline ground and surface water quality conditions and sources of current impairments in the Black River watershed and throughout historic habitat.

Strategy 3. Continue research to determine ecological host species, their abundance in Texas hornshell habitat, their population biology and viability, and how movement patterns affects Texas hornshell distribution.

Strategy 4. Define the hydrological processes in the Black River watershed to determine quantity and connectivity of surface and ground water.

Strategy 5. Secure adequate funding to continue captive propagation research of the Texas hornshell in New Mexico. The intent of this program shall focus on development of methods to produce, rear, and hold juvenile and adult mussels as a short-term, emergency response measure to prevent loss of an important population segment(s) that may result from an unforeseen catastrophic event in the Black River.

Strategy 6. If populations in Texas or Mexico are verified, determine the genetics, ecology, and population viability and compare with the Black River populations.

Issue 6. Outreach Needs There is a general lack of concern, awareness, and understanding about the ecological and economic value of aquatic resources of the Black River. As the largest perennial tributary to the lower Pecos River in New Mexico, the Black River harbors the highest diversity and abundance of native aquatic fauna among all perennial streams in the State. The future of Texas hornshell and aquatic–dependent biota of the Black River will, in large part, depend on the degree of government agencies, non-government agencies, and public support for aquatic ecosystem protection and recovery programs.

Strategy 1. Identify government agencies, non-government agencies, and private interests that can assist with conservation efforts of the Black River and its watershed and gain their support in conservation of the Black River. The support of these stakeholders with programs that impact aquatic resources is critical to a successful conservation effort. Stakeholders should be: apprised of this conservation initiative; provided with educational materials related to the goal, strategies, and progress of this effort; and encouraged to participate in conservation activities.

Strategy 2. Develop and implement an informational program that increases public awareness of the plight of the Texas hornshell and the benefits of maintaining the ecological integrity of the Black River ecosystem and its watershed.

Strategy 3. Identify target audiences, evaluate the need for outreach material for target-specific audiences, and develop appropriate media to convey strategically aquatic conservation messages focused on these specific audiences.

Strategy 4. Seek legislative, agency, and public support to designate waters the Black River as an Outstanding National Resource Water under the Clean Water Act (see Appendix II for more information on this program).

Strategy 5. Encourage public outreach programs which will assist in the prevention and early detection of ANS introduction.

4 IMPLEMENTATION SCHEDULE

Section 4 contains the Implementation Schedule for the Recovery Plan. This schedule, if implemented with appropriate funding, partner support, and agency resources, should enable attainment of the recovery goal in a timely manner. Section 4.1 identifies specific tasks to be implemented to meet the strategies identified in Section 3.2 (Management Issues and Strategies). These are grouped by major categories (survey, research, etc.), and individual tasks are prioritized within each group. Several tasks will be immediate and ongoing and are marked with a bullet.

Section 4.2 presents a suggested time-line for the Implementation Schedule for the next seven years. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision and funding.

4.1 IMPLEMETATION TASKS

❖ *Protect Current Population*

- Monitor extant population of Texas hornshell

1. Continue controlled propagation of the species to develop the infra-structure and protocol for producing, rearing and holding of juvenile and adult mussels including development of a captive rearing management plan
2. Develop procedures to mitigate for loss of mussel populations and/or habitat in the event of a catastrophic event
3. Secure host fish populations

❖ *Protect Current Habitat*

- Identify and implement Best Management Practices and permitting stipulations for activities in the Black River watershed to ensure protection of habitat
- Inform private landowners and land management agencies about the protection of current suitable habitat and assist with implementation of such practices
- Work with the Lower Pecos River Watershed Alliance and other local organizations to encourage an ecosystem approach to watershed protection

1. Work with New Mexico Environment Department and other experts to determine and implement the appropriate ground and surface water quality parameters and frequency for monitoring in the Black River to insure Texas hornshell survival
2. Assess the feasibility of nominating waters of the Black River as an Outstanding National Resource Water under the authority of the Clean Water Act (see Appendix II for more information on this program)
3. Encourage participation of private landowners in Candidate Conservation Agreements with Assurances with USFWS (see Appendix II for more information on this program)
4. Assist private landowners in securing incentive funds for watershed and rangeland restoration projects to improve habitat for the Texas hornshell
5. Investigate and implement methods to ensure adequate water quantity and quality in the Black River for Texas hornshell, such as beneficial use in meeting the Pecos River Compact

- ❖ *Protect and Restore Historic Habitat and Populations*
  - o Participate in state and regional strategies (e.g., Western Zebra Mussel Task Force, 100th Meridian Initiative) to prevent the introduction of aquatic nuisance species
  - o Adopt the Draft New Mexico State Aquatic Nuisance Species Management Plan
  - o Develop and disseminate guidelines for the Black and Pecos rivers that provide information on methods to prevent the introduction and spread of ANS, including updating and enforcing NMDGF regulations in the lower Pecos River basin

  1. Secure host fishes populations
  2. Remove barriers to host fish movement
  3. Identify suitable, secure habitats within unoccupied reaches of the Black River and other historic habitats for establishing additional Texas hornshell populations
  4. Identify areas within historic habitat with potential for rehabilitation as Texas hornshell habitat, and when landowners are willing, restore habitat
  5. Restore Texas hornshell into suitable, secure habitats outside of the middle Black River

- ❖ *Coordinate Actions Across the Watershed*
  - o Identify and secure resources to promote habitat restoration and protection under federal, state, and local programs
  - o Work with Lower Pecos Watershed Alliance to include the Black River as a priority in regional watershed protection plans and activities
  - o Increase enforcement of laws regulating illegal activities along the Black River, including trespass squatting, fishing, and dumping

  1. Engage local, state, federal agencies, private landowners, and the oil and gas industry to promote transportation safety and protect aquatic dependent life of the Black River by improving existing river crossings or by considering alternative transportation routes for heavy truck traffic
  2. Work with land management agencies to determine the best means of restoring rangeland and riparian areas while preserving and protecting water quality
  3. Create a recovery implementation team to coordinate and guide conservation efforts

- ❖ *Research*
  - o Working with the New Mexico Environment Department, determine baseline water quality condition and sources of current impairments in the Black River watershed
  - o Investigate habitat use by juvenile and adult mussels as influenced by hydrologic factors
  - o Determine the number of populations inhabiting the middle Black River and complete population viability analyses of these populations
  - o Define the hydrological processes in the Black River watershed to determine quantity and connectivity of surface and ground water
  - o Continue captive propagation research of the Texas hornshell in New Mexico
  - o Determine biological needs of host fishes and population sizes present and necessary to support Texas hornshell
  - o Investigate population genetics of Texas hornshell in the Black River and compare with other populations

- Determine the number of populations inhabiting the middle Black River and complete population viability analyses of these populations
- Support research focusing on, but not limited to: basic life history, reproductive biology, dispersal and gene flos, and mussel feeding and nutrition

❖ *Information and Outreach*

1. Increase government agency and public understanding and support for federal, state, local and private programs that will promote and enhance ecosystem integrity of the Black River and its watershed
2. Seek legislative, agency, and public support to designate waters the Black River as an Outstanding National Resource Water under the Clean Water Act (see Appendix II for more information on this program)
3. Develop and implement an informational program that increases public awareness of the plight of the Texas hornshell and the benefits of maintaining the ecological integrity of the Black River ecosystem and its watershed
4. Identify target audiences, evaluate the need for outreach material for target-specific audiences, and develop appropriate media to convey strategically aquatic conservation messages focused on these specific audiences

4.2 TEXAS HORNSHELL RECOVERY PLAN IMPLEMENTATION TASKS TIME-LINE

	Recovery Task	Current	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Ongoing
PROTECT CURRENT POPULATIONS	Monitor Texas hornshell populations, including restored populations												
	Develop and implement emergency response plan												
	Establish and maintain captive mussels												
	Secure host fish populations												
PROTECT CURRENT HABITAT	Develop and implement Best Management Practices and permitting stipulations												
	Assist landowners and management agencies with protection of habitat												
	Work with local organizations to encourage an ecosystem approach to conservation												
	Identify water quality standards and enforce water quality standards												
	Nomination as ONRW												
	Develop and implement CCAA												
	Assist in seeking funds for habitat protection on private lands												

	Recovery Task	Current	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Ongoing
PROTECT AND RESTORE HISTORIC HABITAT AND POPULATIONS	Participate in state and regional strategies to prevent the introduction of aquatic nuisance species												
	Adopt and implement the Draft New Mexico State Aquatic Nuisance Species Management Plan												
	Develop and disseminate information on preventing and controlling aquatic species												
	Secure host fish populations throughout historic range, including removing barriers to movement												
	Identify areas in historic range for habitat and species restoration, rehabilitate habitat, and restore mussel populations												
COORDINATE ACTIONS ACROSS THE WATERSHED	Identify and secure resources for habitat restoration and protection												
	Increase enforcement of laws regulations trespass squatting, illegal dumping, and prohibited fishing												
	Work with the Lower Pecos Watershed Alliance to encourage an ecosystem based approach to watershed protection												
	Improve road crossing and implement alternative transportation routes												
	Determine and implement Best Management Practices for restoring rangeland and riparian areas												
	Create and implement a Recovery Implementation Team												

	Recovery Task	Current	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Ongoing
RESEARCH	Life history topics including but not limited to: habitat use by juvenile and adult mussels, populations genetics, feeding and nutrition												
	Habitat topics including but not limited to: baseline water quality condition and sources of current impairments, hydrologic processes of watershed												
	Rearing and recruitment topics, including but not limited to: captive propagation research and determining biological needs of host species												
INFORMATION AND OUTREACH	Increase government and public understand and support for the Black River												
	Information and outreach program and Texas hornshell												

5 APPROVALS

This Recovery Plan for Texas hornshell *Popenaias popeii* is approved by:

Luke Shelby — 8.23.07

Luke Shelby, Assistant Director
New Mexico Department of Game and Fish — Date

Bruce C. Thompson — 8-23-07

Bruce C. Thompson, PhD., Director and Secretary to the Commission
New Mexico Department of Game and Fish — Date

Alfredo Montoya — 8/23/07

Alfredo Montoya, Chairman
New Mexico Department of Game and Fish — Date

APPENDIX I

SUMMARY OF PUBLIC INVOLVEMENT ON THE TEXAS HORNSHELL RECOVERY PLAN

Wildlife Conservation Act
The Wildlife Conservation Act (WCA) [17-2-40.1 NMSA 1978] directs the New Mexico Department of Game and Fish (NMDGF) in the process to be followed for the recovery of endangered and threatened species. Public participation in the recovery plan is detailed in the WCA and includes initial public information meetings, the formation of an Advisory Committee and public review of the document prior to submission to the State Game Commission.

Public Information Meetings
The public meeting is the first step in the Recovery Plan process. Public meetings are held to provide opportunities for individuals and private and public entities to express views about the development of the recovery plan and attendant social or economic impacts, if any, which may result from implementation of the recovery plan. At the meetings, background information about the listing, an explanation of the process, and probably content in general terms of the recovery plan is presented and participation in the recovery plan advisory committee is solicited. The meeting for the Texas Hornshell Recovery Plan was advertised through mailings to private and public organizations, agencies, and individuals, legal advertisements (Albuquerque Journal and Carlsbad Current-Argus for 10 days prior to the meeting) and NMDGF press releases.

7 September 2006, 4 pm – Carlsbad, NM 12 participants, including representatives from local, state, and federal agencies, private landowners, and consultants

Advisory Committee
As directed by the WCA, the Advisory Committee is composed of all those who are willing to participate on the recovery plan, including affected local governments, tribal governments, landowners, state and federal agencies and other interested individuals and organizations. Following the public meetings, NMDGF sent letters to individuals and public and private agencies formally seeking participation on the Advisory Committee. The Advisory Committee for the Texas Hornshell Recovery Plan consisted of 24 individuals from academia, federal, state, and local agencies, conservation organizations, and private landowners:

David Berg, Miami University Ohio
Aaron Curbello, Carlsbad Soil and Water Conservation District
Jim Davis, Private Landowner
Earl Ray Forehand, Private Landowner
Tim Frey, Bureau of Land Management
Mark Gordon, University of Colorado, University of New Mexico
Garth Grizzle, Natural Resources Conservation Service
Robert Howells, Texas Parks and Wildlife, retired
Kris Johnson, U.S. Fish and Wildlife Service
Todd Levine, Miami University Ohio

Joel Lusk, U.S. Fish and Wildlife Service
Steve Massey, Eddy County
Matt McMillian, SWCA Environmental Consultants
Marcus Miller, Natural Resources Conservation Service
Bill Miller, Black River Christian Center
Debra Modrall, Private Landowner
Raquel Montoya, Natural Resources Conservation Service
Marilyn Myers, U.S. Fish and Wildlife Service
Jim Ogden, Private Landowner
Michael Robinson, Center for Biological Diversity
Vanessa Sanchez, U.S. Fish and Wildlife Service
Emile Sawyer, New Mexico Interstate Stream Commission
Shann Stringer, New Mexico Environment Department
Frank Weldon, Eddy County
Steve West, CDCA

The Advisory Committee assisted in the development of the plan through reviews of drafts, contribution of management ideas, and identification of potential problems and opportunities related to recovery. The Background and Situation Analysis section of the Recovery Plan was circulated for review beginning in January 2007 and comments were incorporated in the text. A meeting to discuss and draft the Management Strategy section was held in Carlsbad on 22-23 February 2007. Drafts of the Recovery Plan, including the Management Strategy were circulated to the Advisory Committee and technical experts for review through May 2007 and incorporated into the draft Recovery Plan. The final draft of the Texas Hornshell Recovery Plan was circulated to the Advisory Committee and the public for final review in July 2007. Edits from the Advisory Committee members, NMDGF staff, and public review are reflected in the final Commission approved version of the Recovery Plan.

Additional Public Participation

In addition to the announcements of the public meetings and solicitation for participation on the Advisory Committee, many individual communications (e-mails, phone calls, site visits) were made to local landowners, conservation organizations, and government agencies to engage them in the recovery planning process. The general public, as well as public and private organizations, had the opportunity to comment on the Texas Hornshell Recovery Plan from 18 July through 16 August 2007. Announcements of the public comment period were mailed to individuals and agencies and provided in NMDGF press releases. The Recovery Plan was available electronically on the NMDGF website as well as in hard copy by request. Comments were incorporated into the final draft presented to the New Mexico State Game Commission.

New Mexico State Game Commission Approval

As directed by the WCA, the Recovery Plan was presented to and approved by the State Game Commission on 23 August 2007 in Albuquerque.

APPENDIX II

ADDITONAL INFORMATION ON RECOVERY STRATEGY PROGRAMS

Candidate Conservation Agreements With Assurances - U.S. Fish And Wildlife Service
and
Outstanding Natural Resource Water Designation – New Mexico Environment Department

Candidate Conservation Agreements With Assurances For Non-Federal Property Owners

What are candidate species?
Candidate species are plants and animals for which the U.S. Fish and Wildlife Service (FWS) has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act (ESA), but for which development of a proposed listing regulation is precluded by other higher priority listing activities. The National Oceanic and Atmospheric Administration (NOAA)–Fisheries, which has jurisdiction over most marine species, defines candidate species more broadly to include species whose status is of concern but more information is needed before they can be proposed for listing.

What are Candidate Conservation Agreements (CCA)?
CCAs are formal agreements between the FWS and one or more parties to address the conservation needs of proposed or candidate species, or species likely to become candidates, before they become listed as endangered or threatened. The participants voluntarily commit to implementing specific actions that will remove or reduce the threats to these species, thereby contributing to stabilizing or restoring the species so that listing is no longer necessary. The FWS has entered into many CCAs over the years, primarily with other Federal agencies, State and local agencies, and conservation organizations, such as The Nature Conservancy. Some of these have successfully removed threats to species and listing was avoided.

What are Candidate Conservation Agreements with Assurances (CCAA)?
Conservation of fish and wildlife resources on private lands is critical to maintaining our Nation's biodiversity. However, private property owners may face land use restrictions if species found on their lands are listed under the ESA in the future. The potential for future land use restrictions has led some property owners to manage their lands to prevent or discourage colonization of their property by these species. One incentive property owners need to voluntarily promote candidate conservation on their lands and waters is future regulatory certainty. Therefore, the FWS and NOAA - Fisheries have finalized a policy to establish standards and procedures for developing CCAAs for private and other non-Federal property owners.

This approach to CCAs provides non-Federal property owners who voluntarily agree to manage their lands or waters to remove threats to candidate or proposed species assurances that their conservation efforts will not result in future regulatory obligations in excess of those they agree to at the time they enter into the agreement. Property owners may protect and enhance existing populations and habitats, restore degraded habitat, create new habitat, augment existing populations, restore historic populations, or undertake other activities on their lands to improve the status of candidate or proposed species. The management activities included in the agreement must significantly contribute to eliminating the need to list the target species. Although a single property owner's activities alone may not be sufficient to eliminate the need to list, the activities, if conducted by other property owners on other necessary properties throughout the range of the species, must be sufficient to eliminate the need to list.

In return for the participant's voluntary management, the FWS and NOAA–Fisheries provide take authorization through the section 10(a)(1)(A) process of the ESA, which authorizes issuance of permits that will enhance the survival of the species. The permit would allow participants to take individuals or modify habitat to return population levels and habitat conditions to those agreed upon and specified in the agreement.

What species can be included in a Candidate Conservation Agreement with Assurances?
CCAAs may include plants and animals that have been proposed for listing or are candidates for listing. Species that are likely to become candidate or proposed species in the near future may also be included in an agreement.

In a CCAA, what benefits must the species receive?
The ultimate goal of CCAAs is to remove enough threats to the target species to eliminate the need for protection under the ESA. Before entering into a CCAA and providing regulatory assurances, the FWS must reasonably expect and make a written finding that the species included in the agreement will receive a sufficient conservation benefit from the activities conducted under the agreement. "Sufficient conservation benefit" means that the management actions to be taken would remove the need to list the covered species when combined with actions carried out on other necessary properties. "Other necessary properties" are those on which conservation measures would have to be implemented in order to preclude or remove any need to list the covered species.

Conservation benefits may include reduction of habitat fragmentation rates, restoration or enhancement of habitats, increase in habitat connectivity, maintenance or increase of population numbers or distribution, reduction of the effects of catastrophic events, establishment of buffers for protected areas, and creation of areas to test and develop new and innovative conservation strategies. Recognizing that, while a species is a candidate, a property owner is under no obligation to avoid take, the assessment of benefits would include consideration for what the property owner agrees *not* to do as well as any enhancement measures he or she agrees to undertake. If the FWS and the property owner cannot agree on what constitutes benefits, the FWS would not enter into the agreement.

What assurances does the property owner receive?
The FWS will provide assurances that, in the event a species covered in the agreement is subsequently listed as endangered or threatened, the FWS will not assert additional restrictions or require additional actions above those the property owner voluntarily committed to in the agreement. At the time the parties enter into the agreement, the FWS would issue an enhancement of survival permit under section 10(a)(1)(A) of the ESA authorizing the property owner to take individuals or modify habitat to return the property to the conditions agreed upon and specified in the agreement, provided that the take is at a level consistent with the overall goal of precluding the need to list. The effective date on the permit would be tied to the date any covered species becomes listed.

What must the Candidate Conservation Agreement with Assurances include?
The CCAA with must include:

■ a description of the population levels (if available or determinable) of the covered species existing at the time the parties negotiate the agreement and the existing habitat characteristics that sustain any current, permanent, or seasonal use by the covered species on lands or waters owned by the property owner;

■ a description of the conservation measures that the property owner is willing to undertake to conserve the species covered by the agreement;

■ an estimate of the expected conservation benefits as a result of conservation measures, and the conditions that the property owner agrees to maintain;

■ assurances that the FWS will not require additional conservation measures or impose additional take restrictions beyond those agreed to if a covered species is listed in the future;

■ a monitoring provision that may include measuring and reporting progress in implementation of the conservation measures described above and changes in habitat conditions and the species' status resulting from the measures; and

■ a notification requirement, to provide the FWS or appropriate State agencies with a reasonable opportunity to rescue individuals of the covered species before any authorized take occurs.

The lesser prairie-chicken is a candidate species that will benefit from several Candidate Conservation Agreements under development in Colorado, Kansas, New Mexico, Oklahoma and Texas. Photo by John Shackford

Who can participate in a Candidate Conservation Agreement with Assurances?
A CCAA will involve the FWS, one or more non-Federal property owners, and possibly other cooperators. State fish and wildlife agencies, which have primary jurisdiction over species that are not federally listed, may be a cooperator in any CCAA. Other potential cooperators include neighboring property owners, State or local agencies, Tribal governments, or Federal property owners. Only non-Federal property owners may receive regulatory assurances under the agreement.

Will there be any public notification of Candidate Conservation Agreements With Assurances?
As with other section 10 permits, the FWS will publish a notice in the *Federal Register* when it receives the permit application. We will announce receipt and availability of the application and agreement and will accept and consider comments from the public before making a final decision on issuance of the permit.

What if I sell my land? Is the CCAA transferable?
If a property owner who is party to a Candidate Conservation Agreement with Assurances transfers ownership of the lands included in the agreement, the FWS will regard the new owner as having the same rights with respect to the subject lands as the original property owner if the new property owner agrees to become part of the original agreement.

Whom should I contact to initiate a Candidate Conservation Agreement?
Interested parties should contact the nearest FWS Field Office in their State to discuss potential cooperative opportunities. For information on the final policy and regulations, contact our Headquarters Office at the address below. More information and office addresses can also be found at *http://www.fws.gov.*

U. S. Fish and Wildlife FWS
Endangered Species Program
4401 N. Fairfax Drive, Room 420
Arlington, VA 22203
703/358 2105
http://endangered.fws.gov
February 2004

Outstanding National Resource Waters FAQs

What are Outstanding National Resource Waters?

Outstanding National Resource Waters (ONRWs) are waters that receive special protection against degradation under New Mexico's water quality standards and the federal Clean Water Act. They are designated by the Water Quality Control Commission.

Waters eligible for ONRW designation include waters that are part of a national or state park, wildlife refuge or wilderness areas, special trout waters, waters with exceptional recreational or ecological significance, and high quality waters that have not been significantly modified by human activities.

What waters are currently designated as ONRWs?

In 2005 and 2006, the Water Quality Control Commission designated New Mexico's first ONRWs. The designated waters are:

- the Rio Santa Barbara (west, middle and east forks) within the Pecos Wilderness; and
- the surface waters within the U.S. Forest Service Valle Vidal Special Management Unit.

What is the process for designating an ONRW?

Any person may nominate a surface water for designation as an ONRW by filing a petition with the Water Quality Control Commission. The petition must set forth sufficient justification for the proposed designation. Public notice of the petition must be provided and a public hearing held before the Commission makes a decision on the petition.

What special water quality protection do ONRWs receive?

New Mexico's surface water quality standards designate uses for water bodies, set criteria to protect those uses, and establish provisions to preserve water quality. Examples of designated uses are irrigation, wildlife habitat, livestock watering, municipal and domestic water supply, recreation and aquatic life uses. ONRWs are typically subject to the same water quality criteria as other waters with similar designated uses; however, ONRWs receive additional protection aimed at preserving water quality. Degradation of water quality is not allowed in ONRWs except under very limited circumstances. Where water quality meets or exceeds standards, that higher water quality must be protected.

What are the benefits of ONRW designation?

By protecting against water quality degradation — even in high quality waters where standards are exceeded — ONRW designation benefits all users of the water including any downstream users. If watershed conditions along the ONRW need improvement, designation can help to funnel restoration efforts and financial assistance into the area.

continued →

Does ONRW designation affect existing land uses and activities?

Land-use activities in existence at the time an ONRW is designated will not be affected so long as they are controlled by best management practices and do not result in new or increased discharges of contaminants to the ONRW after designation. Examples of such activities could include recreation, grazing, farming, ditch maintenance and many others.

How does ONRW designation affect future activities on public and private lands in a watershed?

New land uses or activities can proceed if they do not cause any water quality degradation in the ONRW. Proposed activities with the potential to impact water quality would likely be reviewed under existing permitting programs, such as:

- Section 404 permits for discharge of dredge or fill material into a waterway;
- National Pollutant Discharge Elimination System (NPDES) permits; and
- Special-use permits on U.S. Forest Service lands or Bureau of Land Management lands.

These permits could be denied or conditioned to prevent degradation in the ONRW.

Can water quality degradation ever be allowed in an ONRW?

Temporary and short-term degradation may be allowed, but only if it can be shown to result in restoration or maintenance of the chemical, physical or biological integrity of the ONRW. This is the only exception to the strict no-degradation rule. It is intended to allow watershed protection and restoration projects to be implemented where needed in ONRW watersheds even if temporary water quality disruptions occur as a result.

Can facility maintenance and fire prevention activities take place near an ONRW?

Maintenance of existing facilities can continue as long as it doesn't result in new or increased discharges of contaminants into the ONRW. Many fire prevention activities are necessary for the long-term protection of water quality within a watershed; to that end, temporary and short-term degradation associated with such activities may be approved.

If water quality in an ONRW is impaired, what steps are taken by the State to remediate?

The primary means for addressing any impaired water, ONRW or not, is the preparation of a document called a Total Maximum Daily Load (TMDL). The TMDL considers existing pollutant loads and establishes a budget based on meeting the water quality standard in the stream. The budget allocates loads for point sources and nonpoint sources of the pollutant to the stream. The TMDL budget is implemented through discharge permits for point sources and through voluntary, cooperative watershed restoration strategies for nonpoint sources.

If violation of a water quality standard can be tied to a particular point or nonpoint source, whether within or outside of an ONRW, the State has the authority to pursue a direct enforcement action.

Where can I get more information about ONRWs?

The regulations concerning ONRWs are contained in New Mexico's Standards for Interstate and Intrastate Surface Waters at 20.6.4.8 and 9 NMAC. These standards and additional information about ONRWs can be accessed on the New Mexico Environment Department's website at www.nmenv.state.nm.us/swqb/ONRW/. You may also call the Surface Water Quality Bureau at 505-827-2822.