# PRELIMINARY DISTRIBUTIONAL SURVEYS OF FRESHWATER BIVALVES IN TEXAS: PROGRESS REPORT FOR 1992

by

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## ABSTRACT

Fifty-six locations were sampled for freshwater mussels; 55% contained either living or recently dead specimens. Mussels were either not found at other sites, or were represented only by subfossil shells. At least 25 of the 52 unionid species present in Texas were collected during this survey, as was Asiatic clam (Corbicula sp./spp).

Live washboards (Megalonaias nervosa) were taken only in Lake Gonzales and Lake Wood in Gonzales County, and at two locations on the Little Brazos River, Robertson County. Threeridges (Amblema plicata) and southern mapleleafs (Quadrula apiculata) were found at many locations and abundant at several. Tampico pearlymussel (Cyrtonaias tampicoensis) was found from the Little Brazos River to the Rio Grande; living examples were most abundant in the Concho River system. Mussels were found at densities > $1/m^2$ only at one site in Lake Gonzales and two sites on the Little Brazos River.

## INTRODUCTION

Freshwater mussels of the family Unionidae were harvested by Native Americans long before Europeans entered Texas (Kunz 1897; Neck 1982a). Early Spanish explorers sought mussels in Texas rivers as did Americans in later years (Kunz 1897). Harvest has continued through the present.

The gem-quality pearls occasionally produced by freshwater mussels drew attention from both American Indians and Spanish explorers (Kunz 1897). Harvest for pearls continued in the 1800s (Kunz 1897), with a major pearl rush in the Caddo Lake area 1909 through 1913 (Shira 1913). Limited harvest for pearls has continued through the present (Howells 1993).

Unionids in much of the Mississippi Valley came under intense harvest in the 1890s for their shells which were used in the button industry; the shell button industry continued well into the 20th century (Coker 1919). Although some mussels were taken for the button trade in Texas (Neck 1990), many local populations appear to have escaped the overharvest seen elsewhere.

Recently, unionids have again come under intense fishing pressure for shell used in the cultured pearl industry. This new pressure on a valuable and renewable natural resource prompted Texas Parks and Wildlife Department (TPWD) to initiate studies in 1992 of native freshwater mussels and the fisheries they support.

Work by TPWD was confounded at the outset by the general lack of recent baseline information specific to Texas. Previously, Strecker (1931) reviewed mussel distribution in the state. When Read and Oliver (1953) published brief comments on mussels in the Dallas area, they observed that little had been done since Strecker's work. Several papers since have largely reflected limited site-specific studies of species present (Murray 1971, 1972; Littleton 1979; Metcalf 1982; Neck 1982b, 1982c, 1986a, 1986b, 1989a, 1989b; Neck and Metcalf 1988). Prior to 1992, TPWD Inland Fisheries staff had not studied the resource or the fishery.

In early 1992, the U.S. Fish and Wildlife Service (U.S.F.W.S.) became interested in freshwater mussels and their distribution (N. Parker, U.S.F.W.S., Lubbock, Texas; personal communication). This interest reflected concerns over potential losses projected to occur if invading zebra mussels (Dreissena polymorpha), an exotic that had escaped the Great Lakes introduction location, reached Texas and displaced native bivalves. In response to U.S.F.W.S. inquiries, Dr. Harold Murray (Trinity University) and Dr. Ray W. Neck (Houston Museum of Natural Science) independently developed species lists by drainage basin and collection site, respectively.

Initial TPWD efforts centered on a survey questionnaire sent to individuals who had purchased licenses in late 1990 and throughout 1991, with a subsequent report of survey findings (Howells 1993). Following this survey, new regulations on the mussel fishery were proposed, and ultimately passed by the TPW (Texas Parks and Wildlife) Commission, with an effective date of September 1992. One aspect of these new regulations was the establishment of 25 areas along Texas rivers designated as mussel sanctuaries where harvest was

prohibited. Sanctuaries were selected to correspond to general areas of harvest and for geographical convenience (locations that could be easily identified); mussel status at these sites was unknown.

TPWD began this study in spring 1992 to survey present unionid distribution and ascertain the status of mussel populations in sanctuary areas, and to complement and update lists prepared by Neck and Murray in April 1992 which largely reflected museum and university collections often made years or decades earlier. This reports summarizes all TPWD mussel surveys conducted in 1992.

## METHODS

Various habitats were sampled at each collection site examined. Specimens were taken primarily by hand from shoreline deposits of shell, wading in shallow water, or snorkeling in deeper waters. On several occasions, SCUBA was used to search deeper waters and extend bottom time. Early in 1992, a dredge (28 x 81 x 104 cm) similar to that presented in Abbott (1968) was used to collect mussels; however, use of the dredge was ultimately discontinued because of extreme weight and large size.

At several locations where mussel densities were initially estimated to be 1-2/$m^2$ or greater, methods of quantifying abundance were examined. One method involved using a 6.1-m rope stretched between two poles as a transect line. This transect was run by a diver who collected, identified and counted mussels within 0.6 m of either side of the line. A second method involved using a PVC-pipe square (0.25 m on each side) which was randomly placed on the bottom; all mussels within the grid were collected, identified, and counted.

Mussels were designated as live, recently dead, or subfossil following the methods of Buchanan (1980). Additionally, some specimens which had been dead for extended but indeterminent periods were considered "long dead" (e.g., specimens from hostile environments where decomposition of shells was rapid, yet probably not subfossil in nature). Where identification was in question, Dr. H.D. Murray, Dr. R.W. Neck, or both, were consulted.

## RESULTS AND DISCUSSION

### Locations Examined

The following locations surveyed for freshwater mussels are generally presented geographically from east to west, by major drainage basins and from upstream to downstream within each river system.

Trinity River Drainage:

- Eagle Mountain Reservoir (Tarrant County).
  Dredge hauls produced a single living and one recently-dead shell of threeridge (Amblema plicata) and a pair of recent valves from pink papershell (Potamilus ohiensis). Pink papershell had been previously reported for drainages east and west of the Trinity River system; indeed, Strecker (1931) commented on its absence in the Trinity River, and suggested it probably did occur there. This collection confirmed its presence.

Brazos River Drainage:

- Little Brazos River, crossings at State Highway 79 and the first county road downstream (Robertson County).
  These sites contained the largest mussel populations and only dense bed of washboards (Megalonaias nervosa) located in sampling to date. Live specimens taken included washboards, threeridges, southern mapleleafs (Quadrula apiculata), western pimpleback (Q. mortoni), yellow sandshell (Lampsilis teres), bluefer (Potamilus purpuratus), Tampico pearlymussel (Cyrtonaias tampicoensis), and Asiatic clam. Additionally, one or both papershell species (pink papershell and fragile papershell Leptodea fragilis) were represented by shells which were in poor condition (badly eroded and disintegrating), as well as at least one specimen was either Texas heelsplitter Potamilus amphichaenus or fragile papershell. Density estimates (mean N/$m^2$ among three replicate samples) at the county road crossing were:
  - washboard (live) - 4.0
  - washboard (recently dead) - 1.3
  - western pimpleback (live) - 5.3
  - western pimpleback (recently dead) - 6.7
  - southern mapleleaf (live) - 2.8
  - southern mapleleaf (recently dead) - 4.8
  - threeridge (recently dead) - 4.0
  - Asiatic clam (live) - 38.8
  - Asiatic clam (recently dead) - 308.8

  Three crossings upstream of State Highway 79 (Robertson County) were located. The bridge at State Highway 485 allowed no river access although river habitats appeared favorable. Two additional crossings farther upstream on private land were not sampled, but permission was given to examine these areas in the future. Additionally, local residents reported mussels as abundant upstream at Wildcat Bridge Road southwest of Calvert; however, this location was not examined.
- Five crossings downstream of county road below State Highway 79 were investigated (Robertson and Brazos counties).
  (1) Sampling at State Highway 203 produced only a small number of living threeridges. (2) The next crossing downriver could not be examined during the wet conditions at the time. (3) The next crossing downriver consisted primarily of slab-rock and gravel riffles with little sand or mud, did not appear to provide good habitat, and was not sampled. (4) At the next crossing downriver, a burned-out bridge and extensive cane growths blocked access and

the location was not sampled. (5) The final site at State Highway 21 had experienced recent bridge construction; it had silted badly below the bridge and contained asphalt and rock cobble upstream. No bivalves were found.

- Camp Creek Reservoir (Robertson County).
  Collections produced live specimens of Asiatic clam, pondhorn (Uniomerus tetralasmus), and pond mussel (Ligumia subrostrata).
- Boy Scout Lakes (Robertson County).
  Collections produced only live specimens of pond mussel and Asiatic clam.
- Lake Proctor, Leon River (Comanche County).
  This reservoir experienced substantial increases in water level in 1992. Examination of recently dead shells stranded as water levels receded produced specimens of southern mapleleaf, Asiatic clam, and a single specimen of Texas lilliput (Toxolasma texasensis).

Colorado River Drainage:

Colorado River:

- Buchanan Reservoir (Burnet County).
  When examined in mid-1992, this reservoir had dramatically increased in water level over previous recent years. Several recently dead Asiatic clams and small, southern mapleleafs were located on a sand bar adjacent to the dam; otherwise, no other bivalves were found. Local musselers indicated that because of recent increases in water levels, few unionids could be found above 10 m in depth.
- Inks Lake (Burnet County).
  Unlike Buchanan Reservoir immediately upstream, Inks Lake is usually considered a constant-level reservoir. However, local residents indicated that a 3-m drawdown occurs every second year in December for maintenance and repair, resulting in mortality to many mussels in shallower waters. Observations confirmed most specimens above the 3-m level were recently dead; only a few living specimens were found including threeridge, western pimpleback (or southern pimpleback Q. houstonensis), southern mapleleaf, Tampico pearlymussel, and Asiatic clam.

Pedernales River:

- Pedernales River, road crossings south of Fredericksburg (Gillespie County).
  Only Asiatic clams were found alive at both of the two sites examined. However, subfossil Texas fatmucket (Lampsilis bracteata) were found in sandy mud deposited on the flood plain above normal river level. None were found alive although cobble, gravel, sand, and mud substrates at a variety of depths were examined.
- Pedernales River, road crossings between Fredericksburg and Johnson City (Gillespie and Blanco counties).
  Road crossings were located and visually examined, but not sampled. In all cases, substrates consisted of deep, shifting sands which are typically indicative of poor mussel habitat. No unionid shells were apparent in bar and drift areas.

- Pedernales River, Pedernales Falls State Park (Blanco County).
  This location was only briefly examined in November 1992 by shoreline collections. Long-dead shells from southern mapleleaf, threeridge, and Texas pimpleback Quadrula petrina were found, as was a badly-weathered specimen of false spike Quincuncina mitchelli.

Concho River:

- Lake Christoval, Christoval (Tom Green County).
  A small number of living Asiatic clams were the only bivalve found. The bottom was covered with a dense growth of Riccia over rock rubble. The extremely deep layer of Riccia (to about 0.15 m) suggested undesirable conditions for mussels and major nutrient input.
- South Concho River below Christoval dam (Tom Green County).
  Only a small number of Asiatic clams were found alive. This area offered gravel, sand, and mud habitats, but was heavily covered with old tires, cans, and other garbage.
- South Concho River, just above the confluence with Nasworthy Reservoir (Tom Green County).
  This section of river was examined by boat during surveys of Nasworthy Reservoir; however, waters were too deep to sample without diving gear, or too rocky to harbor mussels.
- Middle Concho River, below Twin Buttes Reservoir (Tom Green County).
  Transects were run using SCUBA across branches of the river below both dams at Twin Buttes Reservoir. Neither unionids or their shells were found. However, snorkeling the steep, red-clay walls on both branches yielded a number of relatively large southern mapleleafs (live) as well as Asiatic clams (live).
- Middle Concho River, halfway between Twin Buttes Reservoir and Nasworthy Reservoir (Tom Green County).
  Tampico pearlymussel, southern mapleleaf, and Asiatic clams (live) were taken along reed beds. Growths of Chara and other aquatic plants on the bottom may have limited mussel abundance in the area.
- North Concho River, San Angelo (Tom Green County).
  Early in 1992, portions of the river running through the city of San Angelo were drained for cleaning and repairs. A survey was conducted at this site some days after the water levels had dropped. Local biologists and law enforcement officers reported many individuals had searched the river for pearl mussels. The TPWD survey crew found recently-dead giant floater (Anodonta grandis) extremely abundant; most had been recently opened. Additionally, recently-dead shells of paper pondshell and southern mapleleaf were found, as were those of Asiatic clam.
- Power plant discharge canal, Nasworthy Reservoir (Tom Green County).
  Snorkeling in this location produced a limited number of medium-sized southern mapleleafs (live) and Asiatic clams (live). All mapleleafs were very deeply buried in red clay substrate. Dredge hauls in this canal also produced live Asiatic clams and southern mapleleafs. Some local musselers indicated Tampico pearlymussels occur here as well.

- Nasworthy Reservoir (Tom Green County).
  Numerous locations on the reservoir were sampled by dredge, wading, snorkeling, and with SCUBA. Live specimens collected included Tampico pearlymussel, bluefer, southern mapleleaf, giant floater, paper pondshell (Anodonta imbecillis), and Asiatic clam. Just below the mouth of the South Concho River a bed of subfossil threeridges was located; no living specimens were found although some local musselers claim a few still exist in the reservoir. Subfossil shell fragments of Texas fatmucket Lampsilis bracteata and papershells (Leptodea fragilis or Potamilus ohiensis) were also found near the South Concho River. Additionally, long-dead long fingernail clam (Musculium transversum) were also taken. Quadrant sampling near the South Concho River mouth indicated density of southern mapleleafs was $0.4/m^2$ (20 grid samples).
- Concho River below Nasworthy Reservoir dam (Tom Green County).
  No bivalve specimens were taken in main-channel areas examined by SCUBA between the intake of the TPWD canal and the golf course upriver. However, in the mouth of the TPWD canal and in the mouth of a small tributary creek on the golf course, live southern mapleleafs, Tampico pearlymussels, and Asiatic clams were found.
- TPWD Canal, just inside its mouth and on the TPWD fish hatchery, San Angelo (Tom Green County).
  Just inside the mouth of this canal several live Tampico pearlymussels, bluefers, and southern mapleleafs were collected; live Asiatic clams were extremely abundant at some locations. Sections of this canal on the state fish hatchery were dominated by very large southern mapleleafs (live). Live giant floaters, paper pondshells, and Asiatic clams (large specimens) were also collected; however, neither Tampico pearlymussels or bluefers were found.

Llano River:

- Llano River, adjacent to the Texas Tech University field station, Junction (Kimble County).
  Wading and snorkeling produced only a few subfossil threeridge shells in addition to live Asiatic clams. Much of the substrate was coarse gravel and rock rubble, but areas along mud banks at several locations were devoid of unionids.
- Crab Apple Creek, a tributary southwest of Llano (Llano County).
  Sampling at this location yielded subfossil assemblages similar to those from the Lehmberg Crossing collections. However, a single recently-dead threeridge recovered suggests at least some individuals of this species may still be present in the area.
- Llano River, Lehmberg Crossing west of Llano (Llano County)
  Although this location was extensively sampled by wading and snorkeling, no living unionids were found; Asiatic clam was the only living bivalve observed. Subfossil shells from threeridge, southern mapleleaf, an unidentified pimpleback, giant floater, pistolgrip (Tritogonia verrucosa), and one or both papershells (Leptodea fragilis or Potamilus ohiensis) were found.
  Additionally, a recently dead Texas fatmucket valve was recovered.

- Llano City Reservoir, Llano (Llano County).
  Only live Asiatic clams were taken. Although the reservoir bottom was largely sand, with sand and mud at some sites, no unionids were found.
- Llano River immediately below Llano City Reservoir dam (Llano County).
  Asiatic clams (live) and a single valve from a small, long-dead southern mapleleaf were the only bivalves found. Bedrock and heavy rock rubble indicated poor habitat for mussels.

San Saba River:

- San Saba River, Menard (Menard County).
  Live Asiatic clams were found, as were several small, recently-dead shells from southern mapleleafs. Bottom habitat consisted of gravel and sand, with mud banks at some sites, but no other bivalves were found.
- San Saba River, County Road 1311 crossing (Menard County).
  This location marked the upstream limit of a designated sanctuary area. The site was examined from the crossing to about 200 m downstream into the sanctuary, and about the same distance upstream. Only Asiatic clams were found alive. However, one sand bar produced recently dead Tampico pearlymussel, bluefer, fragile papershell, southern mapleleaf, golden orb Quadrula aurea, Texas pimpleback, and giant floater, suggesting populations of these species may persist in the area.
- San Saba River (San Saba County).
  Collections made along this stretch of river produced subfossil assemblages similar to those from the Llano River at Lehmberg Crossing. No living unionids were found.

Guadalupe River Drainage:

Guadalupe River:

- Guadalupe River, Hunt (Kerr County).
  Although this site was not formally sampled by TPWD, a single living Texas lilliput was collected in summer 1992 by the staff at a local summer camp and was presented to the HOH staff. It was the only unionid they had seen in the area.
- Guadalupe River, boat ramp immediately upstream of Ingram Lake (Kerr County).
  Live Asiatic clams were relatively abundant at this location. No other bivalves were found except for a small, subfossil fragment of the hinge plate from a quadrulid or amblemid mussel. Most of the bottom was bed rock and coarse rock rubble subject to scouring during floods.
- Ingram Lake (Kerr County).
  The only unionid found was paper pondshell (all living) which was common immediately above the dam in 2.5 to 3.5 m of water. Live Asiatic clams were also abundant. The bottom was soft silt over gravel with intermittent patches of Chara sp. Paper pondshells were found laying on their sides on the surface of the silt while Asiatic clams were often found imbedded in the bottom creating a cratered appearance to the substrate.

- Guadalupe River, immediately below Ingram Lake (Kerr County).
  Most of the bottom at this location was bedrock and no bivalves were found.
- Johnson Creek (Kerr County).
  Only two unionid species, represented by subfossil material, were found. Several Texas fatmuckets were found in sand and gravel areas off the Hoot Owl Hollow Road low-water crossing, and a single threeridge valve was also found. Live Asiatic clams were observed.
- Guadalupe River, above dam at Louise Hayes Park, Kerrville (Kerr County).
  Only live Asiatic clams were observed. The bottom was coarse rock and subject to scouring during floods.
- Guadalupe River, immediately below Louise Hayes Park dam (Kerr County).
  Only a few live Asiatic clams were found. However, a single set of subfossil pseudocardinal teeth from a quadrulid or amblemid mussel was also taken. The bottom was largely solid bed rock and without good mussel habitat.
- Guadalupe River, above dam at Center Point (Kerr County).
  Only live Asiatic clams were found at this location; however, the soft mud bottom was similar to that found upriver above Ingram Lake dam where paper pondshells were present.
- Guadalupe River, below water park, New Braunfels (Comal County).
  Several recently dead valves of Texas lilliput were found as were fragments of several other species appearing to be floaters (Anodonta spp.) or papershells (Leptodea fragilis or Potamilus ohiensis). Live Asiatic clams were abundant. Most of the bottom was bedrock; however, soft mud banks lined each side of the river.
- Guadalupe River, camp grounds below State HIghway 46, New Braunfels (Comal County).
  The bottom in this area was largely coarse cobble and rock. Only recently dead Asiatic clams were observed. A local landowner who occasionally harvests mussels indicated he had never observed unionids in the area.
- Guadalupe River and reservoirs below New Braunfels:
  - Lake Dunlap (Guadalupe County),
  - Guadalupe River between Lake Dunlap and Lake McQueeney (Guadalupe County),
  - Lake McQueeney (Guadalupe County), and
  - Lake Placid (Guadalupe County).

  Only living Asiatic clams and long-dead threeridges were found at these locations. Discussions with local residents indicated no living unionids were reported from the area in recent years. Residents also indicated harvest of Asiatic clams for food by some individuals was taking place.
- Guadalupe River, between Lake Gonzales and State Highway 80 (Gonzales County).
  This section of river, just downstream from a mussel sanctuary was examined, but not sampled. River depths averaged approximately 6-7 m (too deep to free-dive safely). Depth-finder reading of bottom types indicated mud at most locations. Consequently, this

stretch of river may support populations of mussels.

- Lake Gonzales (Gonzales County).
  A variety of unionids, as well as Asiatic clam, were taken at this location including, in order of abundance, threeridge, southern mapleleaf, yellow sandshell, bluefer, Tampico pearlymussel, giant floater, washboard, Louisiana fatmucket (Lampsilis hydiana), Texas lilliput, and paper pondshell. Asiatic clams were also abundant. All were represented by living specimens. Local residents on Lake Gonzales indicated the reservoir had held beds of washboard mussels, in one case, several hundred m long; however, the area had been heavily harvested by commercial musselers 2-3 years earlier. Reportedly, a crew of over 50 musselers arrived on one occasion and used a dragline-type dredge to efficiently mine some beds. When TPWD divers examined the site in summer 1992, only one giant floater and one threeridge were found where previously an extensive washboard bed had purportedly been present. A single mussel bed, predominantly of threeridges, was located elsewhere in the reservoir. Density in this bed determined was estimated at 6.2-8.6 threeridges/$m^2$. No other species were taken in transect samples though others were present in the bed and elsewhere in the reservoir. The bed was about 3 m in width and 20 m in length. In five man-days of sampling on Lake Gonzales, only a single living washboard was collected. The reservoir bottom was largely mud, with relatively few other substrates except occasional logs or tree branches.
- Lake Wood (Gonzales County).
  Sampling indicated mussel populations and abundance similar to that observed upstream at Lake Gonzales. However, five live washboard specimens were taken in the upper reaches of the reservoir, and no Louisiana fatmuckets were found.

Blanco River:

- Blanco River, south of Dripping Springs (Hays County).
  Only live Asiatic clams were found. No other bivalves were taken. The bottom was primarily rock and gravel.

San Marcos River:

- San Marcos River, above the State Highway 35 bridge (Comal County).
  Live Asiatic clams were present in abundance; however, no other bivalves were taken. Substrates were usually sand and finer gravel, with occasional mud.
- San Marcos River, at Palmetto State Park (Gonzales County).
  Only Asiatic clams were collected alive. Long-dead washboard, threeridge, southern mapleleaf, and Texas lilliput were found, but were not abundant. The bottom was typically coarse rock, cobble, and deep, shifting sand. In the 1960s, Dr. H.D. Murray had taken living washboards and other species at this location; however, few if any appear to inhabit the area now.
- Oxbow Lake, Palmetto State Park (Gonzales County).
  This oxbow pond, isolated from direct access to the river, was examined twice in 1992. On the first occasion in July, only a single living pondhorn was found. When examined later in the fall, long-dead Texas lilliput, yellow sandshell, Tampico pearlymussel, and giant floater were found along the shoreline.

Diving failed to produce any living specimens. The bottom was primarily soft mud, but with a large amount of submerged tree branches in the western end of the pond and bark chips in the eastern end of the pond. Flooding may periodically reintroduce mussels into this water body.

Comal River:

- Tributary creek near Landa Park Golf Course, New Braunfels (Comal County).
  Only Asiatic clams were found alive at this site. Although the bottom consisted of mud, heavy growths of filamentous algae covered most of the substrate.

San Antonio River Drainage:

- Boerne City Lake (Kendall County).
  This impoundment received substantial runoff prior to examination resulting in dramatically increased water levels. Using snorkeling, the deepest dives of about 6 m only reached the shoreline of the previous year. No bivalves were found.
- Victor Braunig Reservoir (Bexar County).
  Dredge hauls in this reservoir produced only living Asiatic clams. Large specimens, > 40 mm in length, were abundant.

Nueces River Drainage:

- Choke Canyon Reservoir (Live Oak County).
  Casual examination of the shoreline found recently-dead valves from yellow sandshell.

Rio Grande Drainage:

- Rio Grande in the vicinity of San Francisco Creek (Brewster and Terrell counties).
  Two of the three unionids found in this area represent noteworthy collections. A recently-dead Texas hornshell (Popenaias popei) collected at the mouth of San Francisco Creek represents an apparent upstream record for the species in the Rio Grande (R.W. Neck; pers. comm.). Further, a recently-dead Salina mucket (Potamilus salinasensis) taken several km downriver from San Francisco Creek represents a poorly-known endemic species. One recently-dead Tampico pearlymussel was also collected.
- Elm Creek, Eagle Pass (Maverick County).
  Mussels taken included yellow sandshell and Tampico pearlymussel, all recently dead. Additionally, a single valve of Atlantic rangia (Rangia cuneata), a brackishwater species, was also found. Atlantic rangia occurs naturally in the lower Rio Grande, and its shells, both recently-dead and subfossil, are used for road fill and paving. The specimen found had not been dead for an extended period. Whether it indicates the species is present in the area, or was deposited there in fill materials is undetermined.
- Rio Grande River below Falcon Reservoir dam (Starr County).
  Attempts to collect unionids in this area yielded no specimens. Only live Asiatic clams were taken. However, high water at the time of sampling likely blocked access to permanently inundated areas where mussels would have been expected to occur.

- Harlingen City Lake (Cameron County).
  Shells collected along the shoreline by TPWD fishery management biologists were those of Tampico pearlymussel; all were recently dead.
- Rancho Viejo Resaca (Cameron County).
  Collections produced numerous specimens of Tampico pearlymussel and Asiatic clam. The Tampico pearlymussel shells had been dead long enough for nacres to bleach nearly white, but most of their epidermal layer was still intact. All were found under several cm of mud and silt, suggesting they may have been buried during extensive flooding that had occurred earlier in the year.

## SUMMARY

Among 56 locations actually examined for the presence of unionids (Figure 1), 45% were without either living or recently-dead freshwater mussels.

Populations of the four primary sport and commercial species were found. Living washboards were present at only four locations (7%), two adjacent reservoirs on the Guadalupe River and two adjacent sites on the Little Brazos River. They were abundant only at the two Little Brazos River sites. Living or recently-dead threeridges were present at 10 sites (18%), southern mapleleafs at 16 (29%), and Tampico pearlymussels at 14 (25%); additionally, yellow sandshell was present at seven sites (13%).

Mussel beds (> 1/$m^2$) were found only in Lake Gonzales (predominantly threeridges) and in the Little Brazos River (several species). At other locations, unionids were typically scattered about within acceptable habitats at substantially lower densities.

Distribution of species was generally consistent with accounts of Strecker (1931), and unpublished material by R.W. Neck and H.D. Murray (prepared April 1992). Pink papershell was found in a Trinity River reservoir where not previously reported, and Texas hornshell was obtained further upriver in the Rio Grande than previously collected.

In 1931, Strecker (1931) discussed stretches on the Llano River that had been overharvested by pearlers, and portions of the upper Trinity River where urbanization and associated pollution had eliminated mussels. Little more than 20 years later, Read and Oliver (1953) sampled locations in Dallas County where Strecker had reported mussels and found some areas to be lacking living examples. During this survey, places on the Llano, San Saba, Guadalupe, and Pedernales rivers listed by Strecker (1931) and on the lower San Marcos River where H.D. Murray collected specimens in the 1960s (Trinity University unionid collection) were found to contain only subfossil material or long-dead shells. Although overharvest by musselers may have accounted for reduced mussel populations in some instances (e.g., lakes Gonzales and Wood), declines elsewhere likely did not necessarily reflect recent overfishing. For example,

H.D. Murray took washboards and other unionids in the lower San Marcos River in the 1960s in an area wholly within Palmetto State Park. This same location was reexamined twice in 1992, but only a few long-dead shells were found, including a single pair of valves from a very old washboard. The substrate observed during the 1992 sampling consisted of rock, cobble, and deep, shifting sands (generally undesirable mussel habitat). This tends to suggest local environmental changes in the river following Murray's collections over two decades earlier. Logically, commercial harvest in the area would have been observed, if not prevented. Similarly, locations on the Pedernales River south of Fredericksburg which appeared to contain acceptable mussel habitat yielded only subfossil shells of a non-commercial species, suggesting some factor for their decline beyond simple overharvest.

In general, many river stretches through the Texas Hill Country were largely devoid of living unionids. Substrates were often either too hard (bedrock, rock rubble, cobble) or too unstable (deep shifting sand or deep silt); many areas were subject to intense scouring during floods. Mussels often continued to persist in rivers and reservoirs further upriver on the Edwards Plateau and downstream on the coastal plain where conditions were more stable and more favorable.

An additional aspect of sampling in 1992 was the general absence of very small, young mussels almost everywhere. Unionids may show boom-and-bust cycles like those seen in other aquatic organisms, or may so completely fill existing habitats that recently settled juveniles cannot survive. None of the sites examined to date were densely populated enough to prevent successful settling of juveniles. Most populations contained mature adults, somewhat fewer subadults, and few or no small juveniles, with very small juveniles largely nonexistent. This size and age distribution may suggest a boom-and-bust cycle, but is ominously disconcerting as well.

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Figure 1. Texas locations examined for the presence of freshwater mussels (Family: Unionidae) by Texas Parks and Wildlife Department Inland Fisheries staff in 1992.