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Abstract

We analyzed stream inventories, phylogeographic studies, community and population estimates, life history and reproductive biology research, and suitable habitat investigations conducted from 1997-2008, as well as the Arkansas Natural Heritage Commission mussel database, to update the conservation status for all native freshwater unionoid bivalves thought to occur in Arkansas. Prior to this study, Harris et al. (1997) reviewed the distribution and status of 75 freshwater mussels considered native to Arkansas and ranked 22 species as endangered, threatened or special concern. We now recognize 85 mussel taxa in Arkansas; however, some of those have yet to be described or their nomenclature remains in a state of flux. The previous inclusion of *Fusconaia subrotunda* (I. Lea 1831) and *Obovaria subrotunda* (Rafinesque 1820) in the Arkansas native mussel fauna was based on misidentifications. Within the Arkansas mussel fauna, 19 species (22%) are now considered Endangered, 5 species (6%) are ranked as Threatened, 20 species (24%) are of Special Concern, and unfortunately, 1 species has probably been extirpated.

Introduction

Freshwater mollusks are among the most imperiled taxonomic groups in the world, and they constitute 708 of the approximately 7000 species included in the 2002 International Union for the Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (Lydeard et al. 2004). Furthermore, 42% of the 693 recorded animal species extinctions have been mollusks, and 99% of the mollusks that have become extinct were non-marine taxa. Freshwater bivalves of the superfamily Unionoidea are distributed worldwide, but they are most diverse in North America. Between 850 and 900 freshwater bivalve species are recognized; 200 of these species are on the IUCN Red List, and 189 of the listed species are located in the United States (Lydeard et al. 2004).

Within the last 60 years, our rich North American fauna has been decimated by impoundments, sedimentation, channelization, dredging, water pollution, and invasive species (Williams et al. 1993, National Native Mussel Conservation Committee [NNMCC] 1998). Thirty-seven of the 297 known North American taxa are presumed extinct, and another 165 are considered possibly extinct, critically imperiled, imperiled, or vulnerable (Turgeon et al. 1998, Master et al. 2000).

Freshwater mussels influence critical ecosystem

services by linking benthic and pelagic compartments through their large biomass and filtering abilities and have been used as indicators of water quality (NNMCC 1998, Christian et al. 2008, Cope et al. 2008, Vaughn et al. 2008).

To conserve native freshwater mussels, the NNMCC (1998) identified 10 specific problems that included the lack of knowledge regarding current distribution and health of mussel populations. Their suggestions included: 1) determining location, density, species composition, and status of existing mussel communities; 2) gathering historic distribution data and making it available; and 3) gathering information on the occurrence and abundance of mussels valuable for the commercial mussel industry.

Conservation and recovery of this imperiled biological resource will require aggressive pursuit of priority research needs for understanding the life history, distribution, and ecology of freshwater mollusks. Periodic reevaluation of these priorities is required, and to this end, the plenary session of the Freshwater Mollusk Conservation Society's 2007 symposium was structured to provide information to support revision of the National Strategy for the Conservation of Native Freshwater Mussels (NNMCC 1998, Christian and Harris 2008). Product delivery is a crucial part of advancing mollusk conservation from theory to application, and the critical reviews provided for freshwater mussel taxonomy and systematics (Bogan and Roe 2008), reproductive life history (Barnhart et al. 2008), community ecology (Vaughn et al. 2008), landscape ecology (Newton et al. 2008), and toxicology (Cope et al. 2008) provide that link.

Conservation and recovery of unionoid resources at the state and local levels requires the same diligence in delivery of information crucial to conservation efforts. Harris and Gordon (1987) and Harris et al. (1997) reviewed the distribution and status of rare and/or endangered Unionoida (Mollusca: Margaritiferidae, Unionidae) that have occurred in Arkansas. Investigations targeting distribution and status of Arkansas unionoid bivalve species (commonly referred to as clams, mussels, freshwater mussels, naiads; hereafter mussels) have occurred in essentially two distinct phases: pre-1987 phase that targeted determining which taxa occurred within state borders; and post-1987 phase which began systematic surveys of stream systems to determine the distributions and relative abundances of mussels, and establish baseline population estimates for monitoring status and trends. Since Harris et al. (1997), a plethora of stream inventories, phylogeographic analyses, community and population estimates, life history and reproductive biology studies, and suitable habitat investigations have been completed. The purpose of this paper is to provide an updated comprehensive review of the conservation status for all native freshwater unionoid bivalves thought to occur in Arkansas.

Methods

A comprehensive review of all mussel records in the Arkansas Natural Heritage Commission (ANHC)-maintained mussel database (established 2001, Farris et al. 2001) was conducted, and data were grouped into 3 time periods: pre-1986, 1986-1996, and 1997-2008. Species occurrence data were extracted from the database, geo-coded, exported as a shape file, and overlain on an Arkansas drainage map using ESRI ArcMap Version 9.3 to visualize density of species occurrences within each river basin. The ANHC database was queried to determine the number of locality records and live specimens encountered for each species for the 3 time periods, and relative abundance was compared in an attempt to determine population trends (increasing or decreasing). Trend data extracted from the database was also compared with previous species assessments (ANHC 2002, Anderson 2006) to determine if conservation rankings warranted revision since the last comprehensive assessment (Harris et al. 1997). Survey reports, master-of-science theses, taxonomic research reports, and the published literature were searched and summarized regarding mussel occurrences and relative abundances within Arkansas. The locations, level of effort, and results of large geographic scale surveys conducted from 1997-2008 are summarized in Table 1. Major drainage basins within Arkansas are illustrated in Figure 1.

Status determinations and conservation rank terminology for Arkansas freshwater mussels are an amalgamation resulting from review of a variety of synoptic conservation status publications and databases (Williams et al. 1993, Harris et al. 1997, ANHC 2002, Anderson 2006, ANHC 2009a and 2009b, NatureServe (2009), and U.S. Fish and Wildlife Service (USFWS) (2009b). Although conservation rank assignment is based on numerical data extracted from the ANHC database, these data are subject to the bias and relative experience of individual collectors, collected by widely different methodologies, and littered with taxonomic inconsistency due to misidentifications or nomenclature revisions; therefore, conservation rank

Table 1. Summary of major mussel surveys in Arkansas, 1997-2008.

DRAINAGE River/Stream	Source	Access	Stream/River Kilometers	Sites	Sample Method	Richness (Taxa)
			WHITE RIVER			
Buffalo River	Matthews 2007	Continuous Survey	234.9	63	41 timed search; 22 quantitative (m^2 quadrats)	23 + *Corbicula*
Kings River	AGFC 2003 collections	Continuous Survey	52.8	19	Timed Search	18 + *Corbicula*
Little Red River	Winterringer 2003	Point + Continuous Survey	95.7 Middle Fork Little Red River	14	Timed Search; Quadrat Samples	27
Little Red River	USFWS and AGFC 2004-2006	Continuous Survey	120.0 (Archey, Beech, Middle, South forks; Turkey Creek; Big Creek)	32	Timed Search	24
Myatt Creek	Davidson *et al*. 1997	Continuous Survey	23.2	18	Timed Search	21
Spring River	Trauth *et al*. 2007	Continuous Survey	71.3	49	49 timed search; 7 quantitative (m^2 quadrats)	29
South Fork Spring River	Harris *et al*. 2007	Point + Continuous Survey	121.5	53	56 timed search and 9 quantitative (m^2 quadrats)	37
South Fork Spring River	Martin 2008	Point + Continuous Survey	95.0 (AR portion)	30	30 timed search, 7 quantitative (m^2 quadrats)	20
Strawberry River	Harris *et al*. 2007	Point + Continuous Survey	118.9	51	Timed Search	39
War Eagle Creek	AGFC Survey	Continuous Survey	27.5	9	Timed Search	14
White River	Harris and Christian 2000	Point Survey	Discrete Sites	36	14 timed search, 22 quantitative (m^2 quadrats)	32
White River	Harris 2002	Continuous Survey	17.9 Total Lock & Dams 1-3, Guion Reach	49	Timed Search	15
Crooked Creek	Stoeckel 2005	Continuous Survey	128.1	13	Timed Search	8
			ARKANSAS RIVER			
Arkansas River	Ecological Specialists, Inc. 2005a	Continuous Survey	104.6	21	Timed Search (547 samples)	26
Bayou Meto Drainage	Miller and Payne 2002	Point Survey	Discrete Sites	48	Timed Search	16
Big Piney Creek, East and Middle forks	Stoeckel and Davidson 2000	Continuous Survey	Total 85.1	43	Timed Search, 8 quantitative (m^2 quadrats)	21
Illinois Bayou	Harris 2001a	Continuous Survey	35.9	15	Timed Search	21
Fourche La Fave River	AGFC & USFWS 2008	Continuous Survey	50.0	15	Timed Search	22
Illinois River	Harris 2001a	Continuous Survey	25.3	12	Timed Search	18
Petit Jean River						

Table 1 continued. Summary of major mussel surveys in Arkansas, 1997-2008.

DRAINAGE River/Stream	Source	Access	Stream/River Kilometers	Sites	Sample Method	Richness (Taxa)
			OUACHITA RIVER			
Bayou Bartholomew	Brooks et al. 2008	Point Survey	NA	50	Timed Search	35
Caddo, Ouachita, and Saline rivers	Scott 2004, Farris et al. 2005, Christian et al. 2006	Point Survey	NA	33	Timed Search	26
Little Missouri River	Christian and Harris 2004	Continuous Survey	83	131	Timed Search	37
Ouachita River	Harris 1999	Continuous Survey	40	119	Timed Search, 5 quantitative (m^2 quadrats)	37
Ouachita River	Harris 2006	Point Survey	NA	6	6 quantitative (m^2 quadrats)	33
Saline River	Davidson and Clem 2002	Continuous Survey	163	147	Timed Search	41
Saline River	Davidson and Clem 2004	Continuous Survey	81	83	Timed Search	35
Saline River	Harris 2006	Point Survey	NA	4	4 quantitative (m^2 quadrats)	33
			RED RIVER			
Little River	Seagraves 2006	Continuous Survey	27	19	Timed Search, 2 quantitative (m^2 quadrats)	23
Little River	URS 2007	Continuous Survey	2.1	57	Transects	21
Little River	FWS / AGFC	Continuous Survey	56	14	Timed Search, 1 quantitative (m^2 quadrats)	28
			ST. FRANCIS RIVER			
Ditch 10	Ecological Specialists, Inc. 2005	Continuous Survey	3.7	37	Transects, quadrats	17
Stateline Outlet Ditch	Harris 2001b	Continuous Survey	5.6	50	Transects, 1 quantitative (m^2 quadrats)	19
Tyronza River	Wentz 2008	Continuous Survey	70.4	363	Timed searches, 9 quantitative (m^2 quadrats)	33

assignment remains a somewhat intuitive endeavor. A brief discussion of the conservation rank terminology utilized by the various agencies and organizations follows.

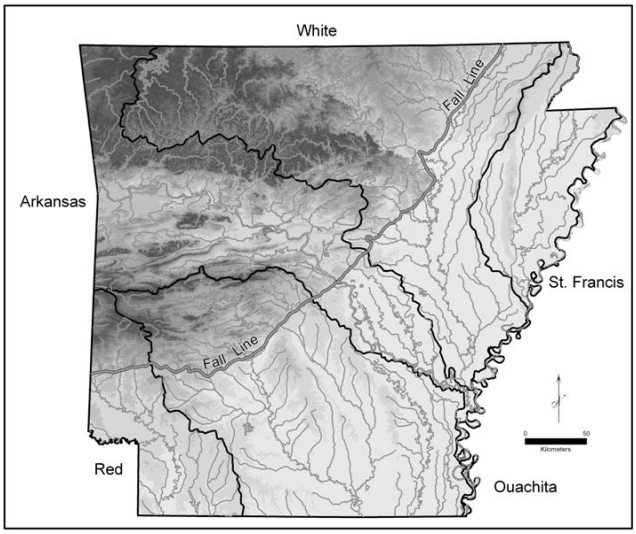

Figure 1. Major drainage basins within Arkansas.

The Endangered Species Act of 1973, as amended, is Federal legislation intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend and provide programs for the conservation of those species, thus preventing extinction of plants and animals. The law is administered by Interior Department's US Fish and Wildlife Service (USFWS) and Commerce Department's National Oceanic and Atmospheric Administration (NOAA) Fisheries (formerly National Marine Fisheries Service or NMFS), depending on the species. An endangered species is an animal or plant species in danger of extinction throughout all or a significant portion of its range. A threatened species is an animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range. A candidate species (candidate) is a plant or animal species for which the USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

The Nature Conservancy and a collection of public and private partners built a network of natural heritage programs in the United States from 1974-1994 to collect and manage data regarding the status and distribution of species and ecosystems of conservation concern. The Nature Conservancy transferred professional staff, databases, and responsibility for scientific standards and procedures to NatureServe (originally the Association for Biodiversity Information) in 1994 (NatureServe 2009). NatureServe utilizes its central conservation databases and the network of natural heritage programs to determine conservation ranks for mussels. Under this system, conservation status of a species or ecosystem is designated by a number from 1 to 5. Rank assignments are made at the Global, National, and State levels. National level ranks are included because the NatureServe network is international but not widely utilized within the United States. Elements of greatest conservation concern are assigned a rank of 1 while those of least concern are assigned a rank of 5. The number is preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global and S = State). As an example, a species may have a Global Rank of G4 and a State Rank of S3 indicating it is secure rangewide, but may be vulnerable within the state. The state rank may not indicate a lower conservation concern than the Global Rank.

Global Rank categories used by NatureServe are: G1 (Critically Imperiled) - at very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines or other factors; G2 (Imperiled) - at high risk of extinction or elimination due to very restricted range, very few populations, steep declines or other factors; G3 (Vulnerable) - at moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines or other factors; G4 (Apparently Secure) - uncommon but not rare, some cause for long-term concern due to declines or other factors; G5 (Secure) - common, widespread, and abundant; GX (Presumed Extinct) - not located despite intensive searches and virtually no likelihood of rediscovery; and GH (Possibly Extinct) - known only from historical occurrences but still some hope of rediscovery. There is evidence that the species may be extinct throughout its range, but not enough to state this with certainty. Examples of such evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching or some evidence of significant habitat loss or degradation; (2) that a species has been searched for unsuccessfully, but not thoroughly enough to presume that it is extinct or eliminated throughout its range. Other ranks include: GNR (Not Ranked) - the global rank is not yet assessed. GNA (Not Applicable) - a conservation rank is not applicable (conservation ranks are not applied to exotic species). Other variants and qualifiers are used to add information or indicate any range of uncertainty. Global ranks may include

"T" ranks, which refer to the conservation status of a species at a subspecies or variety level. A "Q" in the global rank indicates the element's taxonomic classification as a species is a matter of conjecture among scientists. A "?" is used temporarily when there is some indecision regarding the rank assignment. A range may indicate the species rank is intermediate between numeric ranks.

The Research Section of the Arkansas Natural Heritage Commission is the NatureServe network Heritage Program for the state of Arkansas and has the responsibility for assigning the state rank. ANHC staff work with biologists in the state to evaluate and assign state ranks. Following the standard NatureServe methodology, characteristics such as total population size (number of individuals of the species), number of different populations, extent of species habitat, breadth of the species geographic range, population trend (whether a species numbers are increasing, stable, or declining), threats to species (both human and natural) are evaluated.

State ranking definitions (ANHC 2009b) include: S1 (critically imperiled) - often 5 or fewer populations, very steep declines or other factors making it vulnerable to extirpation; S2 (imperiled) - very few populations (often 20 or fewer), steep declines or other factors making it vulnerable to extirpation; S3 (vulnerable) - relatively few populations (often 80 or fewer), recent and widespread declines or other factors making it vulnerable to extirpation; S4 (apparently secure) - uncommon but not rare, some cause for long-term concern due to declines or other factors; S5 (secure) - common, widespread, and abundant; SH (historic occurrence) – known only from historical records with some possibility of rediscovery. Presence may not have been verified in the past 20 to 40 years (this rank may be assigned without the 20 to 40 year delay if only known occurrences were destroyed or species has been extensively and unsuccessfully sought); SU (unrankable) - currently unrankable due to lack of information or due to substantially conflicting information about status or trends; SX (presumed extirpated from the state) - not located despite extensive searches and virtually no likelihood of rediscovery; and SNA (not applicable).

The Arkansas Wildlife Action Plan (Anderson 2006) utilized NatureServe (G1, G2, G3) and ANHC (S1, S2, S3) rankings to develop a draft species list for consideration as "species of greatest conservation need". Species removed from consideration included those that were extinct or those that were common elsewhere and rare in Arkansas because the state is on the periphery of their range. Undescribed species and species with apparently more secure status (G4-G5 and S4-S5) were included on the list if their populations were thought to be in decline or if little was known about their conservation status. Species Priority Scores were calculated by adding G-rank score values (1-16) and S-rank score values (1-5), and then multiplying the resulting raw score by 0.75 if the species was increasing or by 1.25 if the species was declining so that the score reflected trend data. The resulting number was divided by 0.2625 to achieve a 100 point scale (Anderson 2006). Inclusion on the list of Species of Greatest Conservation Need (SGCN) does not confer any regulatory status. The identification of SGCN is part of a process to identify species and groups of species that will be the focus of programs and projects supported by federal funding under the State Wildlife Grant Program.

Conservation status categories (STATUS: State) utilized in this paper follow Williams et al. (1993, revision in preparation) and are defined as: Endangered (E) - a species or subspecies in danger of extinction throughout all or a significant portion of its range; Endangered, probably extirpated (EXT) - a species or subspecies that is probably extinct from the geographic unit being considered; Threatened (T) - a species or subspecies that is likely to become endangered throughout all or a significant portion of its range; Special Concern (SC) - a species or subspecies that may become endangered or threatened by relatively minor disturbances to its habitat, and deserves careful monitoring of its abundance and distribution; Undetermined (U) - a species or subspecies whose historic and current distribution and abundance has not been evaluated in recent years; Currently Stable (CS) - a species or subspecies whose distribution and abundance may be stable, or it may have declined in portions of its range but is not in need of immediate conservation management actions.

Nomenclature generally follows Turgeon et al. (1998). Generic and species reassignments within *Quadrula* based on Serb et al. (2003) have been widely accepted (Williams et al. 2008) and are followed in this paper. Acronyms for museum collections accessed and/or collections visited that may appear in the following results and discussion include: ANSP (Academy of Natural Sciences of Philadelphia), ASUMZ (Arkansas State University Museum of Zoology), FMNH (Field Museum of Natural History of Chicago), INHS (Illinois Natural History Survey), MCZ (Museum of Comparative Zoology, Harvard University), OSUMZ (The Ohio State University

Museum of Zoology), UMMZ (University of Michigan Museum of Zoology), and USNM (United States National Museum, Smithsonian Institution).

Results

Table 2 provides our revised list of Arkansas freshwater mussels of greatest conservation concern (E, T, SC) as well as a synopsis of the conservation status rankings assigned to these species by Williams et al. (1993), Harris et al. (1997), USFWS (2009b), ANHC (2002), and NatureServe (2009). The following discussion addresses federally listed endangered and threatened species first and those that are candidates for listing, followed by species of greatest state concern that are considered endangered or threatened. A select group of Species of Special Concern (S3) and Currently Stable species are addressed with individual species accounts. Appendix I provides our most recent attempt to list all freshwater unionoid bivalves that currently occur or historically have occurred in Arkansas waters along with their global and state rankings.

Federal Listed Species

Arkansia wheeleri (Ortmann and Walker 1912) - Ouachita rock pocketbook. Distribution: Figure 2
STATUS: Federal - Endangered, State – Endangered.

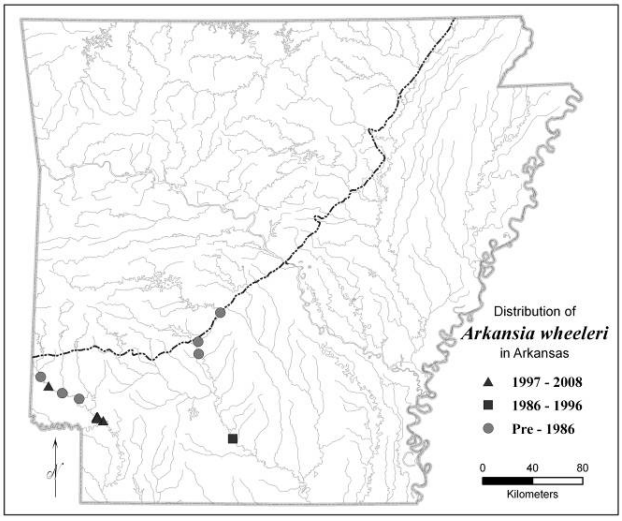

Figure 2. Distribution of *Arkansia wheeleri*.

The USFWS (2004b) published the final recovery plan for *A. wheeleri*, and noted that it was known to exist in approximately 252 river kilometers (rkm) of the Red River system and 179 rkm of the Ouachita River system in Oklahoma and Arkansas. The only known substantial population (fewer than 1,800 individuals) was described as inhabiting a 141-km section of the Kiamichi River, Oklahoma. A smaller, attenuated population (less than 100 individuals) was known to inhabit approximately 111 km of the Little River in Oklahoma and Arkansas, although quality habitat for the species prevailed in only a limited portion (24 km) of that section above the Mountain Fork River. Recent observations of the species in the Ouachita River, Arkansas, were noted as rare and widely separated. The only other recent evidence of the species consisted of single shells recovered from Pine and Sanders creeks, Texas, which enter the Red River near the Kiamichi River.

During 2002-2004, Seagraves (2006) sampled populations to determine relative abundance and demographics, examine reproductive biology, identify suitable fish hosts, and assess and characterize habitat use of *A. wheeleri*. Of 34 fish species tested, glochidia of *A. wheeleri* successfully transformed on 11 species from 3 families including 2 cyprinids, 1 catostomid and 8 centrachids. Optimal hosts with high glochidial transformation success rates for *A. wheeleri* were *Lepomis cyanellus* (>69%), *L. megalotis* (>58%), *L. gulosus* (>51%), *Pomoxis nigromaculatus* (>43%), and *L. macrochirus* (>40%).

Seagraves (2006) surveyed 2 sites in the Ouachita River, Arkansas and 19 in the Little River, Arkansas for *A. wheeleri*, and live individuals were found at 2 locations in Little River downstream of Millwood Lake, which was previously unsurveyed. Quantitative analyses were conducted at each of the 2 sites so that the population size could be estimated within each of the mussel assemblages (= mussel beds, mussel aggregations). At Site 1, *A. wheeleri* was estimated to comprise 200 ± 243 [± 95% confidence interval (CI)] of the 16,700 ± 3,916 mussels within the assemblage. Population size could not be estimated at Site 2, as *A. wheeleri* was not collected during the quantitative analysis. A total of 15 live *A. wheeleri* were examined from 2002-2004 by Seagraves (2006) including 2 specimens from Site 1 and 13 specimens from Site 2.

Historically, *A. wheeleri* was present at 6 sites in the Kiamichi River, OK (Vaughn and Pyron 1995); however, Galbraith et al. (2008) did not find *A. wheeleri* at any of these locations but did report 3 live *A. wheeleri* from a newly discovered mussel assemblage near Moyers, Oklahoma. In the 1990s, *A. wheeleri* was present at 1 site in the Little River (USFWS 2004b). Galbraith et al. (2008) did not find

Table 2. Rankings for mussels of conservation concern in Arkansas.

Species	Federal Listing	Williams et al. 1993	NatureServe 2009	ANHC State Rank	Harris et al. 1997	Revised AR Status 2009
Federal Endangered or Threatened						
Arkansia wheeleri	E	E	G1	S1	E	E
Cyprogenia stegaria	E	E	G1Q	S1?	NR	E
Epioblasma florentina curtisii	E	E	G1	S1	E	E
Epioblasma turgidula	E	E	GX	SX	EX	EXT
Lampsilis abrupta	E	E	G2	S2	T	T
Lampsilis powellii	T	T	G2	S2	T	T
Lampsilis streckeri	E	E	G1Q	S1	E	E
Leptodea leptodon	E	E	G1G2	S1	T	E
Margaritifera hembeli	E	T	G1	SH	NR	E
Quardula fragosa	E	E	G1	S1	E	E
Potamilus capax	E	E	G1G2	S1	T	T
Federal Candidate						
Cumberlandia monodonta	Candidate	T	G3	S1	E	E
Lampsilis rafinesqueana	Candidate	T	G2	S1	T	E
State Endangered						
Alasmidonta viridis	NA	SC	G4G5	S1	E	E
Anodontoides ferussacianus	NA	CS	G5	SU	NR	E
Cyprogenia aberti	NA	T	G2G3Q	S2	SC	E
Epioblasma triquetra	NA	T	G3	S1	E	E
Glebula rotundata	NA	CS	G4G5	SU	NR	E
Lampsilis ornata	NA	SC	G5	S1	U	E
Potamilus alatus	NA	CS	G5	S1	E	E
Quadrula refulgens	NA	SC	G3G4	S1?	NR	E
Simpsonaias ambigua	NA	SC	G3	S1	E	E
Venustaconcha ellipsiformis	NA	SC	G4	S1	NR	E
State Threatened						
Lampsilis sp. B cf *L. hydiana*	NA	NR	NR	S2?	NR	T
Pleurobema cordatum	NA	SC	G4	S2	NR	T
State Special Concern						
Alasmidonta marginata	NA	SC	G4	S3	CS	SC
Cyclonaias tuberculata	NA	SC	G5	S3?	CS	SC
Fusconaia ozarkensis	NA	SC	G3G4	S3	CS	SC
Lampsilis satura	NA	SC	G2	S2	NR	SC
Lampsilis siliquoidea	NA	CS	G5	S3	CS	SC
Lasmigona costata	NA	CS	G5	S3	CS	SC
Ligumia recta	NA	SC	G5	S2	NR	SC
Obovaria jacksoniana	NA	SC	G2	S2	SC	SC
Obovaria olivaria	NA	CS	G4	S3	CS	SC
Quadrula c. cylindrica	NA	T	G3G4	S2	SC	SC
Strophitus undulatus	NA	CS	G5	S3	CS	SC
Toxolasma lividus	NA	SC	G2	S2	SC	SC
Toxolasma texasiensis	NA	CS	G4	S3	CS	SC
Truncilla donaciformis	NA	CS	G5	S3	NR	SC
Uniomerus declivis	NA	CS	G5Q	S1	NR	SC
Uniomerus tetralasmus	NA	CS	G5	S2	NR	SC
Venustaconcha pleasii	NA	SC	G3G4	S3	CS	SC
Villosa arkansasensis	NA	SC	G2	S2	SC	SC
Villosa iris	NA	CS	G5Q	S2S3	CS	SC
Villosa lienosa	NA	CS	G5	S3	CS	SC

A. wheeleri at this site during surveys in 2003–2005; however, they found 2 individuals of *A. wheeleri* in the Little River 1.0 km upstream of the confluence with the Mountain Fork River on the Little River National Wildlife Refuge (NWR).

Spooner and Vaughn (2007) systematically surveyed the mussel fauna at 23 sites in the Mountain Fork River, a major tributary of the Little River in eastern Oklahoma and western Arkansas. Twenty sites were in Oklahoma and 3 sites were in Arkansas. Live mussels representing 22 species of unionids as well as the exotic Asian clam (*Corbicula fluminea*) were found at 18 sites. Total mussel abundance (mussels found/hour) ranged from 0 to 312 with a mean of 40 +/- 84 individuals per site. Mussel species richness per site ranged from 0 to 13, with a mean of 6 (+/- 4). No *A. wheeleri* were found.

The USFWS – Arkansas Field Office and Arkansas Game and Fish Commission (AGFC) conducted additional surveys in Little River during 2006 and 2008. They systematically surveyed 14 sites between Millwood Reservoir and the Arkansas - Oklahoma State Line (~ 56 rkm) and found 28 species of unionids and *Corbicula fluminea*. The number of species per site ranged from 7 to 22 with a mean of 14.7. One live and two dead *A. wheeleri* were encountered during the survey. Quantitative sampling of 1 large mussel assemblage occupying 15,525 m^2 and containing live *A. wheeleri* resulted in collection of 1,067 individuals representing 21 species. The *A. wheeleri* population estimate was 420 ± 730, and the mussel community numerical standing crop estimate was 447,404 ± 73,065.

The *A. wheeleri* Recovery Plan was issued by the USFWS (2004b), and the species is currently undergoing a 5-year status review (USFWS 2007c). Systematic surveys are lacking for the mussel fauna of the Cossatot and Saline rivers, major tributaries of Little River in southwestern Arkansas. The most downstream sections of these two rivers are remote, relatively unspoiled, and may harbor additional populations of *A. wheeleri*.

Cyprogenia stegaria (Rafinesque 1820) - fanshell. Distribution: Figure 3. STATUS: Federal - Endangered, State - Endangered and *Cyprogenia aberti* (Conrad 1850) - western fanshell. Distribution: Figure 4. STATUS: State – Endangered.

Cyprogenia, as currently recognized, is composed of two species found in the Central Highlands of North America, *C. aberti* in the Interior Highlands west of the Mississippi River and *C. stegaria* in the Eastern Highlands east of the Mississippi River (Turgeon et al. 1998, Serb 2006, Graf and Cummings, 2007). The range of *C. aberti* has been previously defined as streams of the Arkansas, White, and Ouachita river basins draining the Ozark and Ouachita mountains of the Interior Highlands (Johnson 1980, Oesch 1995, USDA 1999). In short, all *Cyprogenia* specimens found west of the Mississippi River have been ascribed to *C. aberti* under current taxonomy. However, Call (1895) identified specimens from the St. Francis River, Arkansas as *C. stegaria*, and Frierson (1927) commented on the similarity between *C. aberti* and *C. stegaria* in Arkansas.

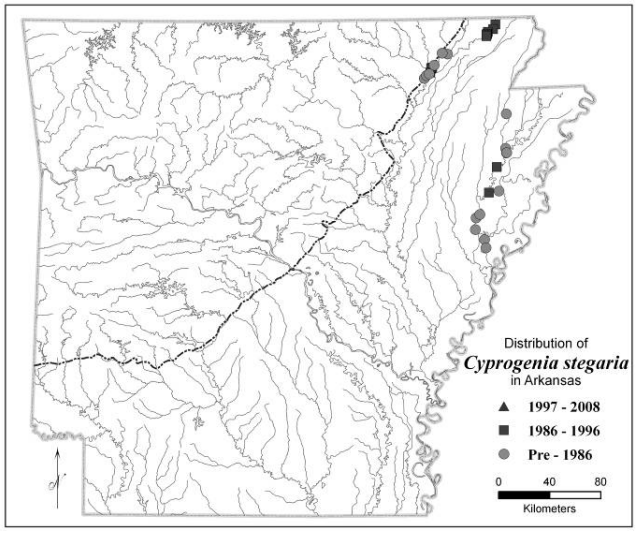

Figure 3. Distribution of *Cyprogenia stegaria*.

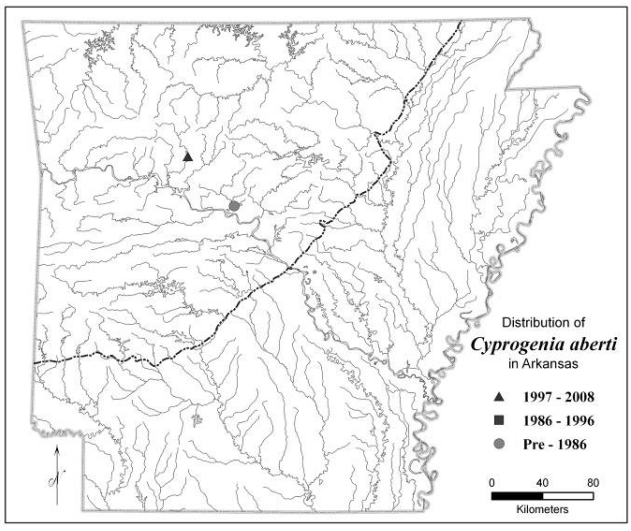

Figure 4. Distribution of *Cyprogenia aberti*.

Serb (2006) conducted a phylogenetic analysis of

C. aberti populations from 13 different localities in Arkansas, Kansas, and Missouri using mitochondrial (mt) DNA sequence data in an effort to determine genetic partitioning and the degree of genetic variation across the extant range of the species. The phylogenetic analyses revealed two well-supported clades (branch support 98-100%), and within these two major clades, *C. aberti* individuals were distributed among five geographically defined clades (branch support >90%): Black River, Arkansas + the federally endangered *C. stegaria*; Arkansas River drainage; White River drainage; 2 Ouachita River drainage clades. The results indicate that *C. aberti* is comprised of as many as five independent lineages, one of which includes the federally endangered *C. stegaria*.

Serb and Barnhart (2008) explored 3 evolutionary associations of *C. aberti*: reproductive traits associated with host preference, geographic distribution, and mitochondrial gene variation. Conglutinates from Fall River, Kansas *C. aberti* females were white, similar to previous observations of Arkansas River system specimens (Barnhart 1997, Eckert 2003). Conglutinates produced by Ouachita and St. Francis drainage *C. aberti* females were either red or brown. The mitochondrial gene analyses included *C. aberti* specimens from the previous phylogenetic study (Serb 2006) as well as new specimens obtained for Serb and Barnhart (2008), and results were similar to Serb (2006) with 2 major clades produced and as many as 5 independent lineages. Parallel geographic structure is present with Ouachita (Ouachita, Saline, Caddo rivers) and White (St. Francis, Buffalo, Strawberry, Current, Black, White rivers) drainage specimens in both major clades. Sympatric individuals from the 2 clades segregate by conglutinate color with red conglutinates (plus the Arkansas River drainage white conglutinates) in 1 major clade and brown conglutinates in the other major clade. Sequence divergence within phylogenetically defined clades corresponding to conglutinate color (red, brown or white) was low, <1%. Values estimated from phylogenetically distinct genotypes (major clades) found among sympatric (same locality) individuals in the St. Francis and Ouachita rivers were >14% and >15% divergent, respectively.

Host fish compatibility may be important in estimating biological diversity and understanding the speciation mechanisms in *C. aberti*. Allopatric pairings of mussel populations and host fish species showed poor transformation success of juvenile mussels. However, differences in host compatibility between red and brown conglutinate-producing individuals were not evident (Barnhart 1997, Eckert 2003, Serb and Barnhart 2008). Differences in host fish compatibility among river drainages provides additional evidence for the distinction among genetically defined, allopatric *C. aberti* lineages, but not for the sympatric lineages in the Ouachita and White rivers (Serb and Barnhart 2008).

Serb and Barnhart (2008) concluded that up to 5 species could be described in the *C. aberti* complex; however, host fish data for the sympatric St. Francis and Ouachita *C. aberti* do not support (but also do not contradict) the hypothesis of sympatric species. Additional life history, geological, nuclear gene sequence, shell morphology, and mussel soft tissue morphology data sets may be required before the speciation mechanisms are understood and the cryptic biological diversity formally described.

For the purposes of conservation efforts, each of the geographically separated *C. aberti* clades must be considered ecologically non-exchangeable (Serb and Barnhart 2008). *Cyprogenia aberti* (Conrad 1850) was described from "Chamber's Ford rapids of Verdigris River, Arkansas", which at that time was part of the Arkansas Territory, now the present day Oklahoma (Tomer and Brodhead 1992). Serb (2006) and Serb and Barnhart (2008) data support restricting *C. aberti* to Arkansas River drainage specimens that represent a distinct phylogenetic species based on mitochondrial gene, conglutinate, and host fish data. Within Arkansas, *C. aberti* (Conrad 1850), when recognized as occurring only in the Arkansas River drainage, is known from single localities in Big Piney Creek (Davidson *et al*. 2000) and Point Remove Creek (UMMZ 98754). The Arkansas' status of *C. aberti* must now be revised from Special Concern to Endangered. The restriction of *C. aberti* to the Arkansas River drainage substantially reduces its global range and known populations, and an updated status review should be conducted to determine if the species warrants protection under the Endangered Species Act.

Cyprogenia stegaria (Rafinesque 1820) was described from the Ohio River, the type has been lost, and a lectotype (ANSP 20215) was selected by Johnson and Baker (1973). Specimens from the Clinch River (Tennessee River drainage) utilized in genetic comparisons in Serb (2006) and Serb and Barnhart (2008), although not topotypic, were typical in shell morphological traits to type drainage specimens. Specimens from the Black and St. Francis rivers, Arkansas are morphologically distinctive and similar in shell morphology to *C. stegaria* from east of the

Mississippi River. Based primarily on the results of Serb and Barnhart (2008), we choose to recognize specimens from the Black and St. Francis rivers within Arkansas as *C. stegaria* sensu lato. It may also occur in the lower White River downstream of the confluence with the Black River, but additional genetic analysis will likely be required to confirm this. *Cyprogenia* has not been reported from recent surveys in the St. Francis River, Arkansas (Posey 1997), and the species is apparently extremely rare within this portion of its range.

Lea (1852) described *Unio lamarckianus* from the Caddo River, Arkansas and the Washitta (Ouachita) River, near Hot Springs, Arkansas; however, the figured holotype (USNM 84306) is labeled White River, Arkansas. The name *Cyprogenia lamarckiana* (Lea 1852) may be available for one of the brown-conglutinate producing clades if it is determined to warrant species level recognition. The molecular genetic data assign specimens from the Caddo, Ouachita and White rivers to one of the brown-conglutinate clades (Serb and Barnhart 2008). Until species relationships are resolved and characters to identify the species are determined, the remaining *Cyprogenia* taxonomic units will be referred to as the *Cyprogenia* species complex (Figure 5).

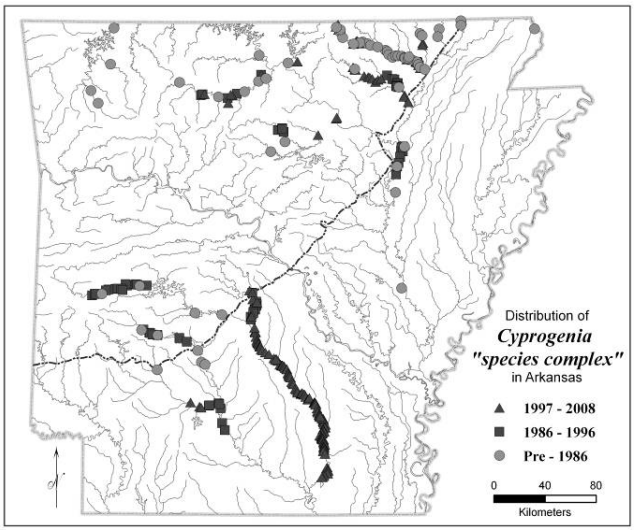

Figure 5. Distribution of *Cyprogenia* species complex.

Epioblasma florentina curtisii (Frierson and Utterback 1916) – Curtis pearlymussel. Distribution: Figure 6. STATUS: Federal - Endangered, State – Endangered.

Surveys were conducted from 1996-2006 in Arkansas's Ozark Highland portions of White River Drainage streams in search of *E. florentina curtisii*, Curtis pearlymussel (Harris et al. 2007). A total of 11 rivers or creeks draining the Ozark Highlands were partially or completely surveyed covering more than 880 stream kilometers using a combination of qualitative and quantitative survey methods to sample 276 sites. Survey efforts were concentrated in the Buffalo, Little Red, Spring, South Fork Spring, Strawberry, and White rivers (Davidson et al. 1997, Winterringer 2003, Matthews 2007, Trauth et al. 2007, Martin 2008).

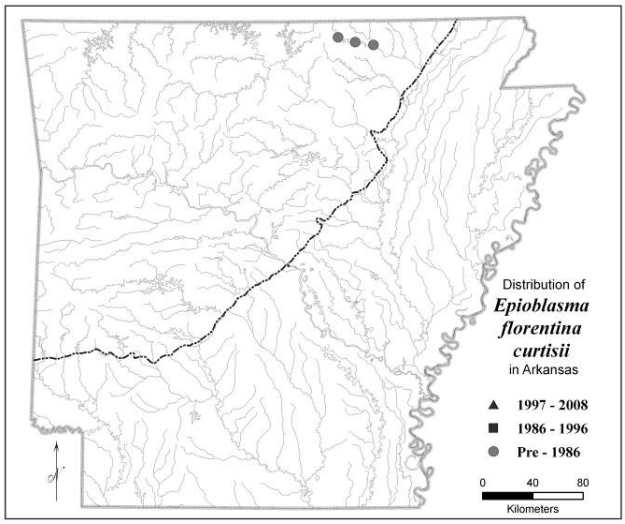

Figure 6. Distribution of *Epioblasma florentina curtisii*.

A review of the literature and museum holdings revealed 4 reported *E. florentina curtisii* localities in Arkansas, 2 in the South Fork Spring River, 1 in the Spring River, and 1 in the Black River. Voucher specimens are available for 1 of the South Fork Spring River sites (University of Arkansas Collections, Fayetteville) and the Spring River at Hardy site (Field Museum of Natural History, Chicago FMNH 59219 and National Museum of Natural History NMNH 160736). The Black River locality record is in doubt as no voucher specimens are available, and the photographic documentation suggests a possible case of mis-labeled field data.

Surveys conducted in the Little Black River, Missouri where *E. florentina curtisii* was last known to occur did not find any live specimens or shell material (Bruenderman et al. 2001). Harris et al. (2007) did not find any live, fresh dead or relict specimens of *E. florentina curtisii* in Arkansas. However, live individuals of *E. triquetra* (snuffbox) were reported for the first time from the Buffalo River (Matthews 2007), and substantial numbers of fresh dead (in muskrat

middens) and living *E. triquetra* were found at 2 sites in the Spring River downstream of Imboden, Lawrence/Randolph County. Mussel assemblages having high density and diversity were located in the Buffalo, Spring, South Fork Spring, and Strawberry rivers. Those sites where the greatest community diversity was recorded warrant future survey attention, as well as continued inspection for the presence of *E. florentina curtisii*.

Epioblasma turgidula (Lea 1858) - turgid blossom. STATUS: Federal - Extinct, State - Extirpated.

Harris and Gordon (1987) listed 1 locality in the Spring River for *E. turgidula* based on previous publications (Johnson 1978) and museum collections (UMMZ 90742), and Harris et al. (1997) provided no additional localities for the species. The USFWS (2007e) concluded that *E. turgidula* is likely extinct and recommended proceeding with a proposed rulemaking to delist the species.

Lampsilis abrupta (Say 1831) - pink mucket. Distribution: Figure 7. STATUS: Federal - Endangered, State - Threatened.

Harris (1999) located 6 live *L. abrupta* at 5 of 119 (4.2%) sites in the Ouachita River upstream of the confluence with the Caddo River. Stratified random m^2 quadrat samples at 1 site yielded a population estimate of 36 ± 73 individuals.

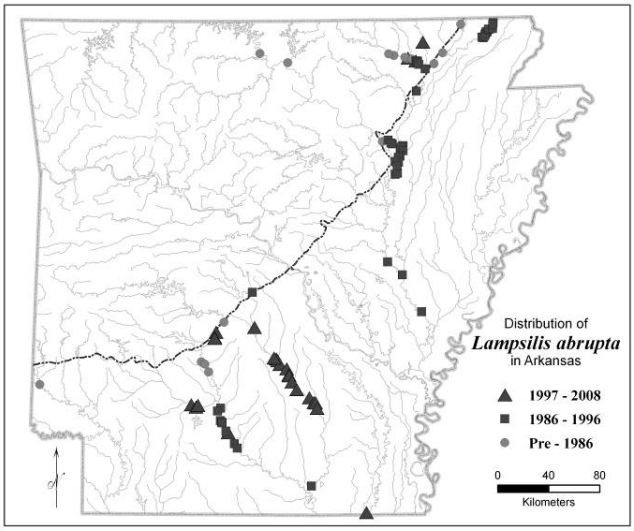

Figure 7. Distribution of *Lampsilis abrupta*.

In the White River, Harris and Christian (2000) re-sampled 22 mussel assemblages that were originally defined and quantitatively sampled by Christian (1995). Three live *L. abrupta* were found at 2 sites (White River Mile (RM) 155.6; White RM 221), and population estimates were 14 ± 49 and 107 ± 214, respectively. Harris (2002) found 1 sub-fossil *L. abrupta* relict in the White River downstream of Lock and Dam 1 at Batesville, Independence County; however, no live individuals were encountered at any of the 49 sites searched from Batesville upstream to Guion, Stone/Izard County.

Davidson and Clem (2002) located 14 live *L. abrupta* at 13 of 147 (8.8%) sites surveyed in 164 rkm of the Saline River. *Lampsilis abrupta* was distributed throughout the survey area and was generally found along inside bendways with substrate comprised of sand with gravel. This species is rare upstream of Arkansas Highway 167 (2 of 62 sites, 3.2%) but was more frequently encountered downstream of Arkansas Highway 167 (11 of 85, 12.9%). Davidson and Clem (2004) found 8 live *L. abrupta* at 6 of 83 (7.2%) sites surveyed in 81 rkm of the Saline River.

Christian and Harris (2004) found 6 live *L. abrupta* at 4 of 131 (3.1%) total sites surveyed in the Little Missouri River, and it comprised 0.17% of the total live mussels examined. All *L. abrupta* sites were located downstream of U.S. Highway 67, Clark/Nevada County.

Harris (2006) found 14 total live *L. abrupta* at 4 sites (n = 1 to 8/site) in the Saline River that yielded population estimates ranging from 49 ± 89 to 883 ± 460. A total of 4 live *L. abrupta* were found at 4 of 6 sites sampled in the Ouachita River that yielded population estimates ranging from 63 ± 131 to 252 ± 503.

Brooks et al. (2008) reported finding only relict *L. abrupta* shells at 50 survey sites in Bayou Bartholomew. George and Vidrine (1993) found live *L. abrupta* individuals in the Louisiana portion of Bayou Bartholomew.

Glebula rotundata (Lamarck 1819) - round pearlshell. Distribution: Little Missouri River. STATUS: State - Endangered.

Glebula rotundata is primarily distributed in Gulf Coast drainages from the Ochlockonee River in Florida west to the Guadalupe River in Texas (Howells et al. 1996). Call (1895) and Gordon et al. (1980) suspected that *G. rotundata* occurred in Arkansas, and Gordon (1983) reported it from a silted in oxbow lake dating 1400 to 1600 A.D. in the Bayou Bartholomew drainage, Drew County, Arkansas. However, Brooks et al. (2008) did not find *G. rotundata* in their recent survey of Bayou Bartholomew.

A single specimen of *G. rotundata* was reported

from the Little Missouri River, Clark/Nevada County (Christian and Harris 2004, Anderson 2006). Additional genetic analyses are underway to confirm the identity of the Little Missouri River specimen.

Lampsilis powellii (I. Lea 1852) - Arkansas fatmucket. Distribution: Figure 8. STATUS: Federal - Threatened, State - Threatened.

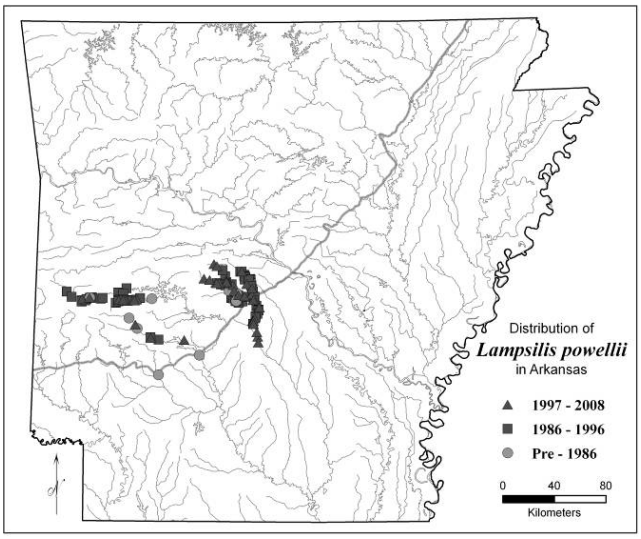

Figure 8. Distribution of *Lampsilis powellii*.

Substantial survey effort has been expended since Harris et al. (1997) to further define the range and conservation status of *L. powellii*. Harris (1999) reported results of a mussel survey encompassing approximately 40 rkm of the Ouachita River from downstream of Remmel Dam (forming Lake Catherine) to the confluence with the Caddo River. Sample effort included 119 sites investigated with timed searches at 23 sites yielding 2780 specimens, semi-quantitative quadrat sampling at 15 sites (51 m^2 quadrats) yielding 526 specimens, and quantitative sampling of 5 mussel assemblages (94 m^2 quadrats) yielding 618 specimens. A single *L. powellii* individual was encountered approximately 11.1 rkm downstream of Interstate 30 and likely represents the downstream limit for the species in the Ouachita River.

Davidson (1997) recorded 34 species from among 548 specimens collected at 4 sites in the most downstream 16 rkm of the Little Missouri River (confluence with Ouachita River at Tates's Bluff upstream to Riffe Ford). Christian and Harris (2004) reported results for 131 sites surveyed in the Little Missouri River between Arkansas Highway 195 south of Delight, Pike County, downstream to Riffe Ford, a distance of approximately 83 rkm. A total of 3533 live mussels were collected during the survey representing 37 species. No *L. powellii* were found in the Little Missouri River during either survey.

During 2001-2002, Davidson and Gosse (2003) surveyed approximately 4 rkm of the Saline River at the confluence with Holly Creek (Holly Creek Bottoms) near Haskell, Saline County. Five mussel assemblages were sampled qualitatively yielding 264 specimens distributed among 24 species. Two of the assemblages were further sampled quantitatively by excavating m^2 quadrats (n = 5, n = 12) yielding an additional 242 specimens represented by 21 species. A total of 3 *L. powellii* were found at 2 of the 5 assemblages.

Davidson and Clem (2002, 2004) surveyed approximately 240 rkm of the mainstem Saline River from near Tull, Grant County to the northern boundary of Felsenthal National Wildlife Refuge (NWR). Davidson and Clem (2002) located 95 mussel beds (area $\geq$100 m^2, $\geq$10 mussels/m^2) and 52 mussel concentrations (area <100 m^2 and/or <10 mussels/m^2) in approximately 164 rkm and examined 11,204 individuals representing 41 species. Eighteen *L. powellii* specimens, representing 0.16% of total mussels, were found at 9 sites, extending the known range approximately 42 rkm downstream to U.S. Highway 270 between Poyen and Prattsville, Grant County. Davidson and Clem (2004) located 74 mussel beds and 9 mussel concentrations in 81 rkm between Arkansas Highway 15 and the northern boundary of Felsenthal NWR and examined 10,112 mussels representing 35 species. No new *L. powellii* sites were found by Davidson and Clem (2004) in this downstream segment of the Saline River.

During 2003-2004, Scott (2004), Farris et al. (2005), and Christian et al. (2006) sampled populations to determine relative abundance and demographics, examine reproductive biology, identify suitable fish hosts, and assess and characterize habitat use of *L. powellii*. Study sites included 33 localities on the Saline, Ouachita, and Caddo rivers in the Ouachita Mountains Ecoregion of western Arkansas where live *L. powellii* were previously known to occur. Harris and Gordon (1988) sampled 30 of the 33 sites in the original *L. powellii* status survey. In the Saline River drainage, 5 sites were located on the main stem of the Saline River, 4 on the Alum Fork, 7 on the Middle Fork, and 1 on the North Fork in Grant and Saline counties, Arkansas. In the Ouachita River drainage, 5 sites were located on the main stem of the Ouachita River, 8 on the South Fork, and 1 on the North Fork in

Polk and Montgomery counties, Arkansas. The final 2 sites were located on the main stem of the Caddo River in Pike County. A total of 137 *L. powellii* were found at 19 of the 33 sites surveyed. *Lampsilis powellii* abundance was reduced when compared to values reported by Harris and Gordon (1988), where 151 *L. powellii* were reported from 29 sites. Slightly fewer individuals (14) were located overall and 21 sites had fewer *L. powellii*, while 7 sites showed an increase in abundance when compared to Harris and Gordon (1988). *Micropterus punctulatus* and *M. salmoides* are the optimal fish hosts, while *Ambloplites ariommus*, *Lepomis cyanellus*, *L. megalotis*, *L. macrochirus*, and *M. dolomieu* appear to be marginal hosts with low (<1%) juvenile transformation success (Scott 2004, Christian et al. 2006).

The USFWS initiated a 5-year status review of *L. powellii* in September 2006 (USFWS 2006). The USFWS – Arkansas Field Office and AGFC with assistance from the USDA Ouachita National Forest conducted a range wide status assessment for *L. powellii* during 2006 and 2007. A total of 92 sites were surveyed, and more than 100 person/hours of search time were expended resulting in 4,762 live mussels collected. Results from this survey yielded 15 new sites (South Fork Ouachita River [1], Caddo River [1], Ouachita River [1], Middle Fork Saline River [3], Alum Fork Saline River [9]) for *L. powellii* not previously documented within its range. Catastrophic declines have occurred in the Caddo River, South Fork Ouachita River, South Fork Saline River, and North Fork Saline River since the surveys of Harris and Gordon (1988) and Burns and McDonnell (1992a, 1992b). Habitat instability due to land use changes and instream gravel mining are thought to be the primary causes of the decline in *L. powellii* abundance.

An analysis of lampsiline species closely related to *L. powellii* using mitochondrial DNA sequences from 2 independently transmitted mitochondrial genomes failed to detect any species diagnostic nucleotide substitutions differentiating *L. powellii* and *L. siliquoidea* (Harris et al. 2004; R. Hoeh, Kent State University, personal communication, 2009). Additional genetic analyses utilizing more specimens and also another gene region (Internal Spacer Region – ITS) have been completed for the *L. powellii* – *L. siliquoidea* clade. The results of the ITS analysis also failed to corroborate the species level validity and taxonomic distinction of *L. powellii*. Additional analyses using AFLP (amplified fragment length polymorphism) PCR (polymerase chain reactions) and total genomes of specimens of *L. powellii* and *L. siliquoidea* are in progress as a final attempt to validate the specific identity of *L. powellii*. In addition, comparisons of *L. powellii* and *L. siliquoidea* using geometric morphometric analysis of shell shape and traditional morphometric analysis of glochidia shape from Scanning Electron Microscopy (SEM) images are underway to determine if morphological characteristics for the 2 currently recognized taxa are significantly different.

Lampsilis streckeri Frierson 1927 - speckled pocketbook. Distribution: Figure 9. STATUS: Federal - Endangered, State - Endangered.

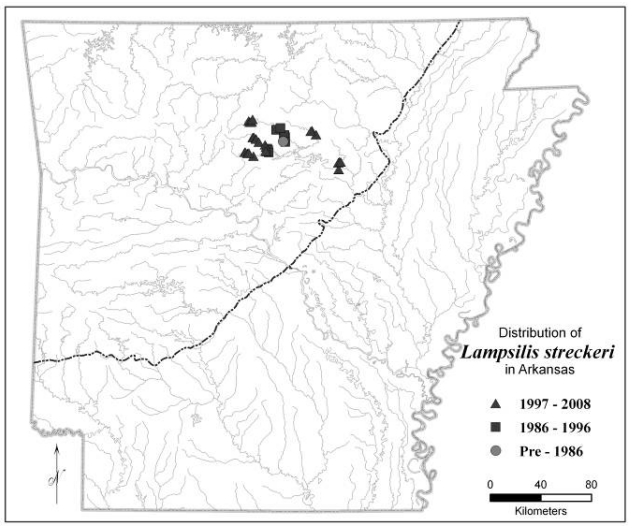

Figure 9. Distribution of *Lampsilis streckeri*.

Winterringer (2003) sampled populations in the Middle Fork Little Red River (MFLRR) to determine relative abundance and demographics, examine reproductive biology, identify suitable fish hosts, and assess and characterize habitat use of *L. streckeri*. Winterringer (2003) tested 22 fish species for their host potential, and *L. streckeri* glochidia successfully transformed on 7 centrarchid species, with the highest transformation success recorded for *L. cyanellus* (>36% transformation rate), *L. megalotis* (>20% transformation), and *L. gulosus* (>18% transformation).

Winterringer (2003) extended the known range of *L. streckeri* in the MFLRR upstream approximately 69 rkm to near Leslie, Searcy County. Collections by the USFWS and AGFC extended the known range an additional 16 rkm upstream to near the confluence with Little Red Creek (USFWS 2007a). Surveys conducted

in 2004-2006 rediscovered extant *L. streckeri* populations in Archey, Beech, South and Turkey forks of Little Red River and a previously undocumented *L. streckeri* population was discovered in Big Creek, a south flowing Little Red River tributary downstream of Greers Ferry Reservoir (Davidson and Wine 2004, Davidson 2005, USFWS 2007a). The current known range includes the MFLRR from the influence of Greers Ferry Reservoir upstream to the confluence of Little Red Creek (approximately 101 rkm), the South Fork Little Red River from Arkansas Highway 95 upstream to near the western boundary of Gulf Mountain Wildlife Management Area and the Ozark National Forest (approximately 23 rkm), the Archey Fork Little Red River from approximately 1.6 rkm upstream of U.S. Highway 65 upstream to the confluence with Castleberry Creek (approximately 26 rkm), lower Turkey Fork (approximately 3.2 rkm), Beech Fork Little Red River (approximately 18 rkm), and Big Creek (approximately 16 rkm) (USFWS 2007a).

The USFWS and AGFC conducted a comprehensive threats assessment survey for *L. streckeri* during 2004 - 2005 and identified several threats associated with land use practices including unrestricted cattle access to streams, eroding stream banks, and gravel mining (Davidson and Wine 2004, Davidson 2005). Since 2005, a new threat to *L. streckeri* has evolved in the form of exploration and development of natural gas reserves in the Fayetteville Shale formation. Potential impacts include dewatering or decreased base flows, habitat fragmentation, increased sedimentation, pollution runoff, and chemical spills (USFWS 2007a).

Conservation measures to benefit *L. streckeri* include development of a comprehensive conservation strategy (USFWS 2005) to protect existing populations and restore or enhance suitable habitat upstream of Greers Ferry Reservoir in advance of possible reintroductions. A programmatic Safe Harbor Agreement was signed in November 2005 by the USFWS Arkansas Field Office, the AGFC, the Natural Resources Conservation Service, and The Nature Conservancy to help implement the conservation strategy and encourage private landowner conservation efforts.

The overall population trend since listing has increased due to the discovery of the additional populations. However, given the potential threats, *L. streckeri* should remain an Endangered species as defined by the Endangered Species Act (USFWS 2007a).

Leptodea leptodon (Rafinesque 1820) - scaleshell. Distribution: Figure 10. STATUS: Federal - Endangered, State - Endangered.

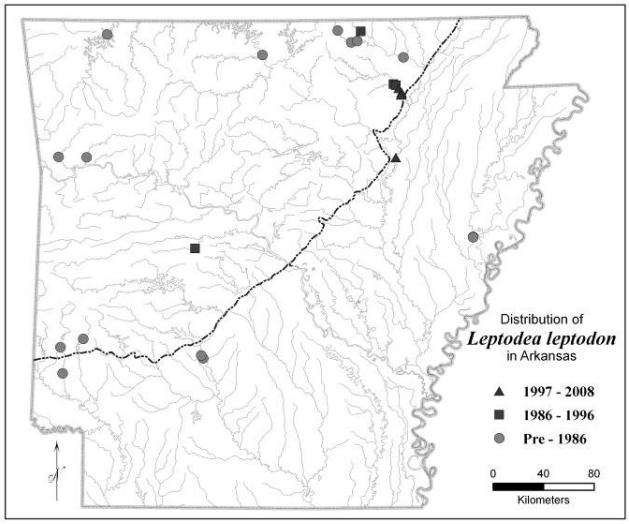

Figure 10. Distribution of *Leptodea leptodon*.

Harris and Christian (2000) reported a single live *L. leptodon* from the White River downstream of Newport, White County. This probably represents the downstream limit for *L. leptodon* in the White River drainage as it is considered an Interior Highlands species that prefers small to medium sized rivers in Arkansas (USFWS 1998, 1999, 2004a). Stoeckel and Moles (2002) resurveyed portions of the South Fourche LaFave River using both qualitative and quantitative methods in search of *L. leptodon* that was reported by Harris (1992). Stoeckel and Moles (2002) examined 2,664 live mussels distributed among 19 species; however, no live or relict *L. leptodon* were encountered.

The USFWS (2007f) initiated a 5-year status review of *L. leptodon*. Systematic surveys at known sites where *L. leptodon* has occurred historically are needed to determine its status in Arkansas.

Margaritifera hembeli (Conrad 1838) - Louisiana pearlshell. Distribution: Figure 11. STATUS: Federal - Endangered, State - Endangered.

M. hembeli is provisionally added to the state mussel fauna based on Smith (2001) mapping a single locality from Bayou Dorcheat, Columbia County. Mussel specific surveys are lacking for Bayou Dorcheat and most Red River tributaries in the southwestern portion of the state.

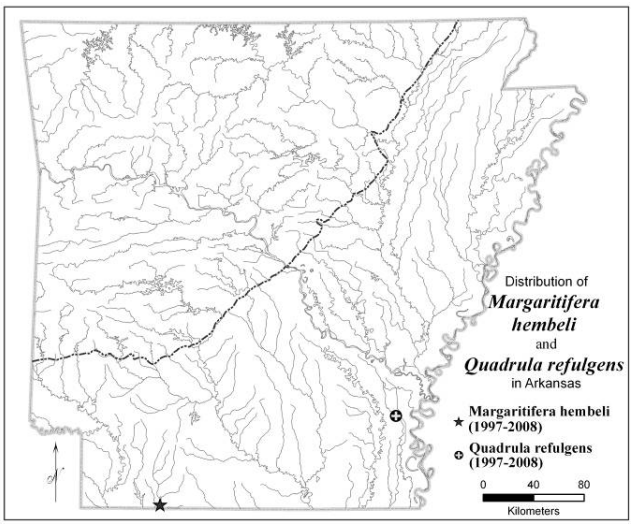

Figure 11. Distribution of *Margaritifera hembeli* and *Quadrula refulgens*.

Quadrula fragosa (Conrad 1835) - winged mapleleaf. Distribution: Figure 12. STATUS: Federal - Endangered, State - Endangered.

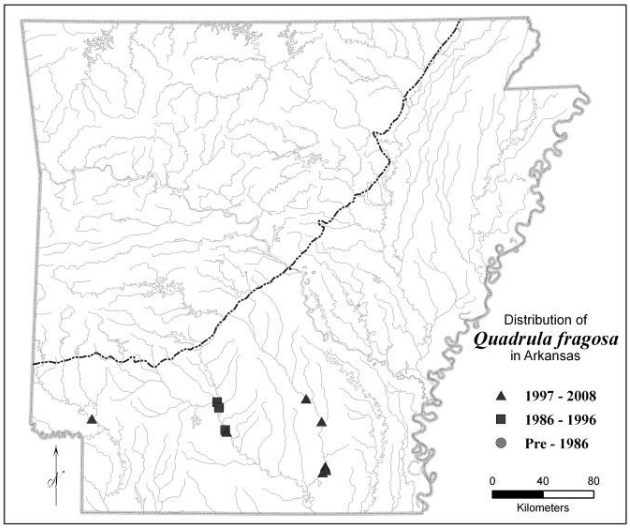

Figure 12. Distribution of *Quadrula fragosa*.

Davidson and Clem (2002, 2004) surveyed approximately 240 rkm of the mainstem Saline River from near Tull, Grant County downstream to the northern boundary of Felsenthal NWR. Davidson and Clem (2002), in a survey of 159 rkm of the Saline River, reported 1 live *Q. fragosa* specimen approximately 3.2 rkm downstream of Mt. Elba in substrate that consisted of gravel with sand. This site is a substantial distance (approximately 109.7 rkm) upstream of the confluence with the mainstem Ouachita River. Davidson and Clem (2004) reported 8 live *Q. fragosa* specimens (representing 0.08% of the total mussels encountered) from 6 sites in the Saline River downstream of Arkansas Highway 15, Bradley County to Felsenthal NWR, a distance of approximately 81 rkm.

Harris (2006) conducted stratified random quadrat sampling for *Q. fragosa* population estimates at 10 sites, 6 in the Ouachita River and 4 in the Saline River. *Quadrula fragosa* was found in 4 of the 6 Ouachita River mussel assemblages sampled and at all 4 assemblages in the Saline River. The 2 Ouachita River assemblages where *Q. fragosa* was not found were positioned in more upstream, higher gradient portions of the river than the assemblages where *Q. fragosa* was detected. *Quadrula fragosa* was found at depths ranging from <1.0 m in the Saline River (Site SRB 141) to >10.0 m in the Ouachita River (Sites ORB 79B and ORB 152). A total of 55 live *Q. fragosa* were sampled from the 4 Saline River sites (range of n = 6 to 27), and population estimates ranged from 510 ± 253 to 9,217 ± 4,114. A total of 22 *Q. fragosa* were sampled from the 4 Ouachita River sites (range of n = 2 to 9) where they were found, and population estimates ranged from 217 ± 261 to 1,770 ± 1,227.

Quadrula fragosa is known to occur in approximately 72.4 rkm of the Ouachita River beginning at the downstream end of the Little Missouri River and extending downstream to Site ORB 27M of Posey (1997). *Quadrula fragosa* has not been found in the remainder of the Little Missouri River despite substantial sampling effort by Davidson (1997) and Christian and Harris (2004). Harris (2005) found *Q. fragosa* approximately 850 m upstream of Site ORB 79B in habitat not typically supporting a high density, species rich mussel assemblage. Additional effort to define *Q. fragosa* distribution within the major and minor mussel assemblages defined by Posey (1997) would be appropriate since the species was not recognized during the initial survey effort. *Quadrula fragosa* is known to occur in approximately 105 rkm of the Saline River as determined by Davidson and Clem (2002, 2004). Population estimates for *Q. fragosa* in the remaining assemblages where it was found by Davidson and Clem and periodic monitoring of selected assemblages throughout the reach would be appropriate.

Galbraith et al. (2008) resurveyed sites in the Kiamichi River, Oklahoma and surveyed additional sites in the Little River, Oklahoma to determine the status of federally listed and other rare species of

mussels in rivers of southeastern Oklahoma. They found individuals that genetic analysis confirmed to be *Q. fragosa* at 4 sites in the Little River. Densities of *Q. fragosa* ranged from 0.13-0.53 individuals/m^2. A single relict *Q. fragosa* (ASUMZ 1960) was encountered in the Little River downstream of Millwood Dam, Little River/Hempstead County, Arkansas during surveys for *A. wheeleri* (Seagraves 2006).

The USFWS recently initiated a 5-year status review for *Q. fragosa* (USFWS 2009a). As part of this review, additional survey effort should be expended in the Little River and its major tributaries, the Cossatot and Saline rivers, to determine *Q. fragosa*'s status in the Red River drainage of Arkansas.

Potamilus capax (Green 1832) - fat pocketbook. Distribution: Figure 13. STATUS: Federal - Endangered, State - Threatened.

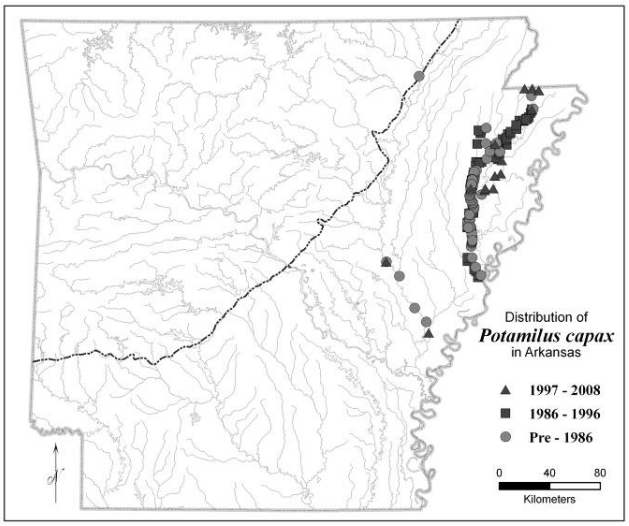

Figure 13. Distribution of *Potamilus capax*.

Potamilus capax has been the subject of intense research, survey, and conservation efforts over the last 10+ years, and is probably the most studied mussel in Arkansas over that time period. Reports of *P. capax* in the White River have been sporadic with no reports of live specimens since the 1960s (Harris and Gordon 1987), until Harris and Christian (2003) found a single live specimen of *P. capax* in the main channel White River at Gunbarrel Reach (RKm 17.7-20.0). In addition, Ecological Specialists, Inc. (2006) reported a weathered *P. capax* shell from the White River at DeValls Bluff, Prairie County.

The Arkansas State Highway and Transportation Department (AHTD) (2001) found *P. capax* at the U.S. Highway 64 crossing of the St. Francis River at Parkin, Poinsett County (St. Francis River RKm 127.0). The subsequent relocation effort to minimize bridge construction related impacts from a 300 m-long reach resulted in the recovery of 5,540 total mussels representing 28 species, including 23 (0.4%) live *P. capax* (AHTD 2001).

Stansbery and Stein (1982) surveyed the project site at Parkin (among others) in August 1978 and collected a total of 337 specimens representing 21 species; however, *P. capax* was not collected at that time. Ahlstedt and Jenkinson (1991) summarized the survey results of 144 mainstem and tributary (ditch) sites covering approximately 400 rkm. Ahlstedt and Jenkinson (1991) defined the area of the St. Francis River from Allen Bayou (RKm 89.0) upstream to the Siphon's Access near Marked Tree, Poinsett County (RKm 249.6) as the "Lower River". They surveyed 35 sites within that area, but found no live *P. capax*. Posey (1997) sampled 4 mussel assemblages between RKm 121.2 and RKm 136.8 but no *P. capax* were encountered. The discovery of *P. capax* in the St. Francis River at Parkin appears to represent a recent range extension or a population increase to levels detectable by standard qualitative survey methods. Wentz (2008) reported the first *P. capax* specimens from the Tyronza River where he encountered 13 live specimens from among 4,030 total mussels. The confluence of the Tyronza and St. Francis rivers is approximately 1.8 rkm upstream of Parkin, Cross County, Arkansas.

During April and May 2005, Ecological Specialists, Inc. (2005b) performed a mussel relocation from approximately 3.7 km of Ditch 10 in Craighead and Poinsett counties, Arkansas. A total of 4,524 unionids representing 17 species were recovered from Ditch 10, and 16 of these individuals were *P. capax*. These 16 specimens were relocated to Stateline Outlet Ditch, Mississippi County, for future monitoring.

Stateline Outlet Ditch (Ditch 81) has received the most attention since 2000 due to the need for channel maintenance (dredging) of 5.6 rkm to improve hydraulic conveyance for flood control. Harris (2001b) quantitatively sampled 50 transects (2,225 m^2 quadrats), recovered 31 live *P. capax*, and estimated the total *P. capax* population within the 5.6 rkm reach at 3,072 ± 121.

As part of formal consultation under the Endangered Species Act, the USFWS issued a Biological Opinion requesting the removal and

relocation of all *P. capax* in the area to be dredged. The Biological Opinion directed that "…approximately 3,000 specimens of *P. capax* will need to be translocated from Stateline Outlet Ditch…" In Spring 2002, the US Army Engineer Research and Development Center (ERDC) performed a systematic recovery and relocation of *P. capax* from Stateline Outlet Ditch prior to maintenance dredging (Miller et al. 2003). A total of 2,042 *P. capax* were relocated to 2 sites in the St. Francis River and 1 site in Ditch 29.

In March 2005, following the maintenance dredging operations in Summer/Autumn 2002, a second quantitative sample effort was conducted over the same 5.6 rkm of Stateline Outlet Ditch using the same methodology as Harris (2001b). Fifty sampled transects (2,859 m^2 quadrats) yielded 64 live *P. capax*, and the total *P. capax* population estimate was 6,763 ± 1,553. *Potamilus capax* population size structure was similar among the 2001, 2002, and 2005 sample events. Although 2,000+ *Potamilus capax* individuals were removed from the population (Miller et al. 2003) and channel maintenance (dredging) operations affected approximately 50% of the channel (Miller and Payne 2006), population size reportedly doubled during the period from 2001 to 2005. Without substantial recruitment as a factor, other contributions may have been horizontal migration (upstream or downstream) by *P. capax* into the sample reach or vertical migration where *P. capax* individuals reside at depths >15 centimeters below the substrate during temporal or seasonal phases, resulting in an underestimate of population size with the sample methods that were employed. Either explanation falls outside the bounds of current concepts regarding distance of horizontal and vertical mussel migrations. Peck et al. (2007) offers some insight with 2 short term (3-month) movement studies of *P. capax* in Stateline Outlet Ditch resulting in mean displacement of approximately 20 m and maximum displacement of 150+ m. Both of these distances are greater than previously published distances for mussel movements (Balfour and Smock 1995, Amyot and Downing 1997, Schwalb and Pusch 2007).

Miller and Payne (2005) suggested the status of *P. capax* is improving within the St. Francis watershed, and the recent distribution and population data previously summarized do not suggest otherwise. However, threats to water quality and physical habitat essential to *P. capax* populations within Arkansas continue to manifest themselves. For instance, in Autumn 2008, a chemical release into Stateline Outlet Ditch from approximately 2 rkm upstream in Missouri killed fish and mussels in an approximately 5 rkm reach of Stateline Outlet Ditch. Miller and Payne (2006) and Payne et al. (2007) stated that Harris et al. (1997) recommended *P. capax* be down-listed to threatened. We continue to consider the status of *P. capax* within Arkansas as threatened, which in no way contradicts its range-wide listing status of endangered under the Endangered Species Act, as amended. The USFWS (2007d) is currently conducting a 5-year status review for *P. capax*.

Federal Candidate Species

Cumberlandia monodonta (Say 1829) - spectaclecase. Distribution: Figure 14. STATUS: Federal - Candidate, State - Endangered.

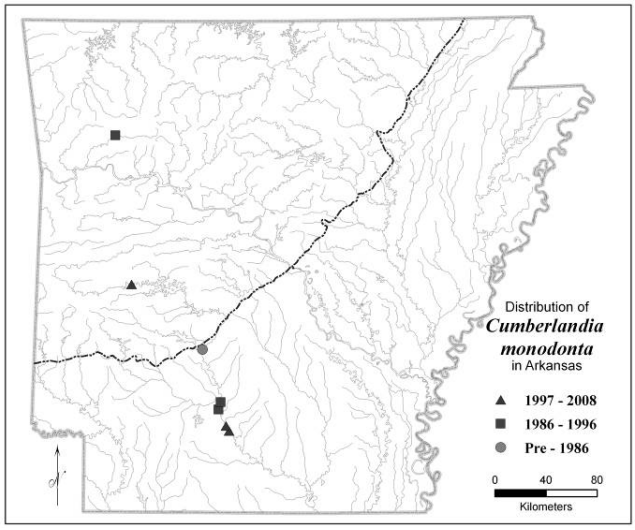

Figure 14. Distribution of *Cumberlandia monodonta*.

Cumberlandia monondonta is now known from 6 localities in Arkansas, 5 in the Ouachita River and 1 in the Mulberry River. New localities discovered since Harris et al. (1997) include the Ouachita River immediately downstream of U.S. Highway 79B in Camden, Ouachita County, represented by 1 live specimen and the Ouachita River immediately downstream of the Ouachita National Forest Drag Over Access, Montgomery County, represented by 1 weathered relict specimen.

Butler (2002) summarized the range-wide status and threats to *C. monodonta*. The USFWS (2007g) considers the range-wide threats to *C. monodonta* to be of high magnitude.

Lampsilis rafinesqueana Frierson 1927 - Neosho mucket. Distribution: Illinois River. STATUS: Federal - Candidate, State - Endangered.

Harris (1998) conducted a status survey of *L. rafinesqueana* in Arkansas and found it at 19 of 22 survey sites in the Illinois River, Washington and Benton counties. Although *L. rafinesqueana* was the third most abundant species collected (157 live individuals, 12.6% of total mussels) from the approximately 50 rkm surveyed, there was little evidence of recent recruitment. The AGFC surveyed 2 sites in 2005, and 76 live *L. rafinesqueana* (26% of total mussels) were found at a site upstream of Robinson Road bridge while 16 live *L. rafinesqueana* were collected 800 m downstream of Chambers Spring Road.

The AGFC and USFWS conducted a comprehensive status survey for *L. rafinesqueana* in the Arkansas portion of the Illinois River in 2008. Live specimens of *L. rafinesqueana* were collected at 9 of 15 survey sites. There was a 32% decline in number of survey sites versus the Harris (1998) status survey and a 53% decline in the number of sites inhabited by *L. rafinesqueana*. Sixty-seven percent of the sites with *L. rafinesqueana* present were represented by 3 or fewer live individuals. *Lampsilis rafinesqueana* was the fourth most abundant species in this portion of the river, but 3 sites accounted for 85% of *L. rafinesqueana* individuals (52) collected during this survey. Of the 15 survey sites, only 2 appear stable with the rest in decline and extirpation imminent. No mussels were collected at the AGFC 2005 sites during 2008, further documenting the precipitous decline of mussels in the Arkansas portion of the Illinois River. The species has not been found in surveys of other tributaries of the Arkansas River in Arkansas (Harris and Gordon 1987, Harris et al. 1997).

State Endangered Species

Alasmidonta viridis (Rafinesque 1820) - slippershell mussel. Distribution: Figure 15. STATUS: State – Endangered

Three additional localities for *A. viridis* have been recorded since Harris et al. (1997). In 2003, 1 live *A. viridis* was found and released in the Buffalo River upstream of the Arkansas Highway 7 crossing at Pruitt, Newton County. Martin (2008) collected 2 specimens from the South Fork of the Spring River, but these were initially misidentified (as *Venustaconcha pleasii*) until they were processed as voucher specimens and catalogued as ASUMZ 5020 - 5021. Weathered dead specimens were collected from the White River upstream of Batesville, Independence County (Harris 2002). This diminutive species continues to be extremely rare and elusive in Arkansas.

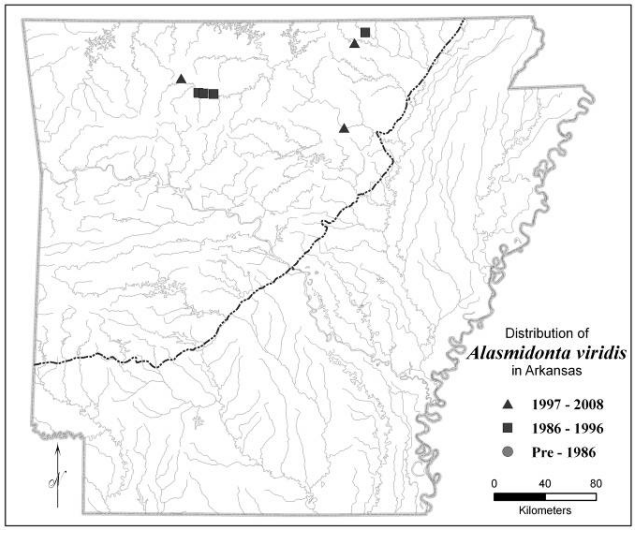

Figure 15. Distribution of *Alasmidonta viridis*.

Anodontoides ferussacianus (I. Lea 1834) - cylindrical papershell. Distribution: Little Red and St. Francis rivers. STATUS: State - Endangered.

There are no recent records for *A. ferussacianus* from Arkansas. Its occurrence in Arkansas is based on UMMZ records from the Little Red River (UMMZ 105556) and the St. Francis River at Marked Tree, Poinsett County (UMMZ 130108). We expect *A. ferussacianus* to occur in the Arkansas River drainage based on museum specimens collected in extreme eastern Oklahoma (A. Bogan, North Carolina State Museum of Natural History, personal communication, 2009).

Cyprogenia aberti (Conrad 1850) - western fanshell. Distribution: Refer to Figure 4. STATUS: State - Endangered.

See account and discussion under *C. stegaria*.

Epioblasma triquetra (Rafinesque 1820) – snuffbox. Distribution: Figure 16. STATUS: State – Endangered.

Butler (2007) summarized the range-wide conservation status and threats of *E. triquetra*. In

Arkansas, Matthews (2007) found 2 live *E. triquetra* from a single site representing the first reported occurrence in the Buffalo River. Harris et al. (2007) found 5 live *E. triquetra* in the Spring River downstream of Imboden, Lawrence/Randolph County, as well as numerous fresh dead specimens (ASUMZ 2821 - 2831, 3013 - 3016, and 3250 - 3251) in muskrat middens scattered along approximately 5 rkm. *Epioblasma triquetra* is apparently more abundant in the Spring River than previously thought; however, it continues to be one of the rarest mussels in the state.

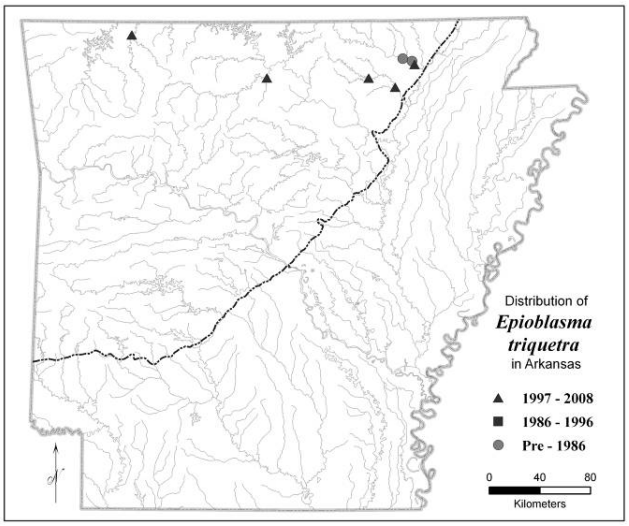

Figure 16. Distribution of *Epioblasma triquetra*.

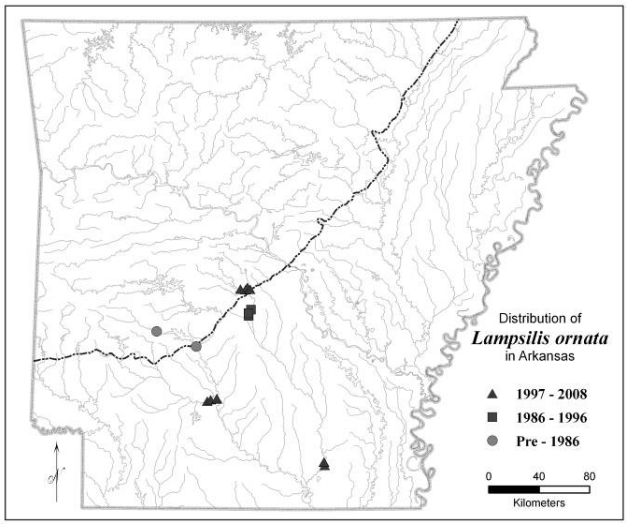

Figure 17. Distribution of *Lampsilis ornata*.

Lampsilis ornata (Conrad 1835) - southern pocketbook. Distribution: Figure 17. STATUS: State - Endangered.

Harris et al. (1997) considered the taxonomic status of *L. ornata* (listed as *L. excavata* in Harris and Gordon 1987) in Arkansas uncertain. Subsequent molecular studies (Harris et al. 2004) confirmed that *L. ornata* occurs in Arkansas. It appears confined to the middle reaches of the Caddo and Ouachita rivers, and occurs in the mainstem of the Saline River from the Fall Line to near the mouth, all in the Ouachita River drainage. Recent status surveys for *L. powellii* conducted by the USFWS - Arkansas Field Office and AGFC found *L. ornata* at 2 sites in the Alum Fork Saline River. Davidson and Clem (2002, 2004) did not identify *L. ornata* from the Saline River; however, no effort was made to differentiate *L. ornata* from *L. cardium*. During quantitative quadrat sampling at 4 locations, Harris (2006) encountered 2 live *L. ornata* at 1 site. Additional specimens have been collected from the Saline River at Benton, Saline County, and Little Missouri River near the confluence with the Ouachita River, Clark/Ouachita counties. The Arkansas population is apparently disjunct from the primary distribution of *L. ornata* in eastern Gulf Coast drainages from the Escambia River, Florida west to the Amite River, Louisiana (Vidrine 1993, Williams et al. 2008).

Potamilus alatus (Say 1817) - pink heelsplitter. Distribution: Figure 18. STATUS: State - Endangered.

Five additional locations are available for *P. alatus*. Miller et al. (2001) reported the first record of *P. alatus* from the White River drainage, finding 3 live specimens in the White River at De Valls Bluff, Prairie County. In 2001, Memphis District Corps of Engineers personnel encountered *P. alatus* at 3 sites in the St. Francis Floodway at county road bridge crossings in Lee and St. Francis counties (M. Smith, U.S. Army Corps of Engineers, personal communication, 2009). One live *P. alatus* was encountered by AHTD personnel during a 2002 survey of the St. Francis River Cut-off, AR Highway 50, St. Francis County, prior to bridge pier scour maintenance activities.

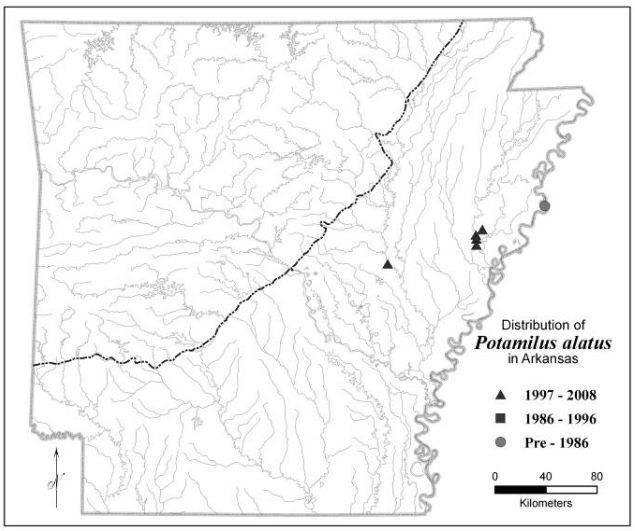

Figure 18. Distribution of *Potamilus alatus*.

Quadrula refulgens (Lea 1868) - purple pimpleback. Distribution: See Figure 11. STATUS: State - Endangered.

Williams et al. (2008) state that *Q. refulgens* is endemic to the Gulf Coast of Mississippi and Louisiana from the Pascagoula River drainage west to the Lake Ponchartrain drainage, citing distributional information from Vidrine (1993) and Jones et al. (2005). A single specimen of *Q. refulgens* (ASUMZ 5018) was collected in May 2002 from Bayou Macon at Arkansas Highway 1, Desha County, and its identity was confirmed by molecular genetic analysis (J. Serb, University of Iowa, personal communication, 2009). Brooks et al. (2008) did not report *Q. refulgens* from Bayou Bartholomew in Arkansas; however, no effort was made to differentiate *Q. refulgens* from *Q. pustulosa* during the survey (D. Hayes, Arkansas State University, personal communication, 2009).

Simpsonaias ambigua (Say 1825) - salamander mussel. Distribution: Black, Spring, and Little Red rivers. STATUS: State - Endangered.

Harris and Gordon (1987) reported 3 site records for *S. ambigua* in Arkansas: Black River at Black Rock, Lawrence County; Spring River at Imboden, Lawrence/Randloph County; and Little Red River at Clinton, Van Buren County. No additional sites have been recorded for *S. ambigua*, despite substantial survey efforts in each of the rivers from which it has been reported (Winterringer 2003, Davidson and Wine 2004, USFWS 2005, 2007a, Harris et al. 2007, Trauth et al. 2007, Martin 2008).

Venustaconcha ellipsiformis (Conrad 1836) – ellipse. Distribution: Figure 19. STATUS: State - Endangered.

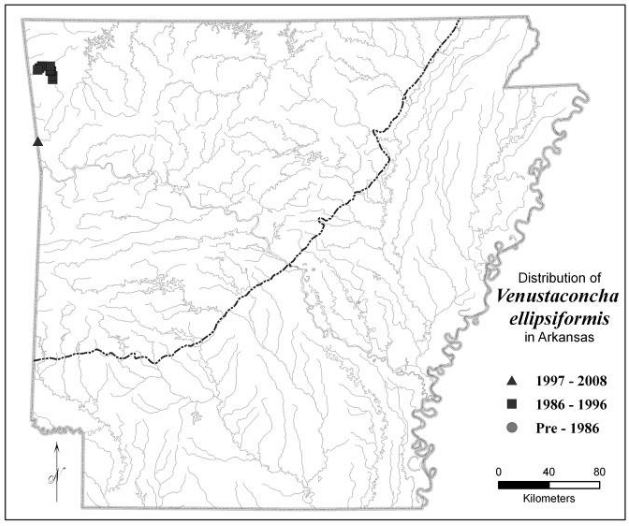

Figure 19. Distribution of *Venustaconcha ellipsiformis*.

The Arkansas' distribution of *V. ellipsiformis* is restricted to the Arkansas River drainage, while its congener, *V. pleasii*, is found only in the White River drainage (Gordon 1980, Riusech and Barnhart 2000). In 1994, Harris (1998) collected only 5 live *V. ellipsiformis* from 22 sites surveyed in the Illinois River. In 2008, the AGFC and USFWS recorded only 1 live specimen from 15 sites surveyed.

This species has a broad distribution in the central United States including Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Ohio and Wisconsin (Allen et al. 2007), but *V. ellipsiformis* is on the southwestern periphery of its range in Arkansas. The low population numbers and restricted distribution of *V. ellipsiformis*, with known localities only in the Illinois River and Lee Creek, mandates that it be considered endangered within Arkansas.

State Threatened Species

Lampsilis sp. B cf. *L. hydiana* - undescribed Red River fatmucket. Distribution: Figure 20. STATUS: State - Threatened.

Turner et al. (2000) found unusual patterns of population fragmentation possibly indicative of taxonomic differentiation within *L. hydiana*. Harris et al. (2004) conducted a phylogenetic analysis of several lampsiline species occurring in Arkansas with

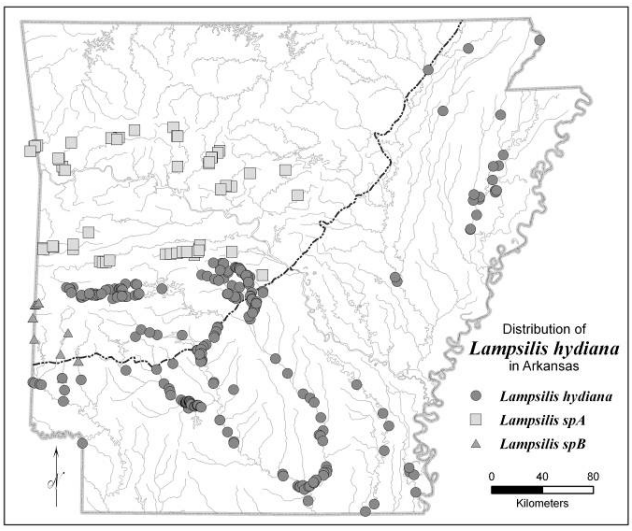

Figure 20. Distribution of *Lampsilis hydiana*, *L.* sp. A cf. *L. hydiana*, and *L.* sp. B cf. *L. hydiana*.

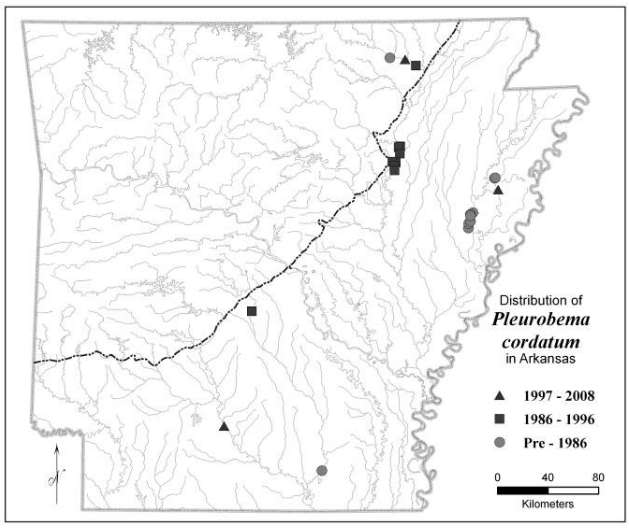

Figure 21. Distribution of *Pleurobema cordatum*.

emphasis on resolving relationships within clades that included *L. hydiana*. Results revealed that populations previously considered *L. hydiana* in Arkansas and Oklahoma were actually composed of 3 distinct taxonomic units. *Lampsilis hydiana* occurs in the Arkansas, Red, Ouachita and White river drainages and can be syntopic with the undescribed taxa. *Lampsilis* sp. A cf. *L. hydiana* occurs in high gradient tributaries to the Arkansas River, primarily in Arkansas, and *Lampsilis* sp. B cf. *L. hydiana* occurs in high gradient tributaries to the Red River, primarily in Oklahoma. When the 2 undescribed species co-occur with *L. hydiana*, it is usually in the transitional habitat between the Arkansas or Red river floodplain (*L. hydiana*) and the higher gradient streams traversing the Boston or Ouachita mountains (*L.* sp. A cf *L. hydiana* or *L.* sp. B cf. *L. hydiana*).

Pleurobema cordatum (Rafinesque 1820) - Ohio pigtoe. Distribution: Figure 21. STATUS: State - Threatened.

The identification of *P. cordatum* in Arkansas is problematic due to convergence of shell morphological characteristics with *P. rubrum* and *P. sintoxia*. Christian et al. (2008) were unable to firmly document *P. cordatum* in Arkansas due to lack of useable DNA sequences from topotypic specimens (type locality Ohio River). Roe (2002) and Williams et al. (2008) describe *P. cordatum* as inhabiting medium to large rivers. In Arkansas, specimens morphologically similar to topotypic *P. cordatum* occur in the Ouachita, White, and St. Francis river drainages (Christian et al. 2008).

State Special Concern Species

As a result of our reevaluation, 23 species are now ranked as Special Concern in Arkansas. A select group of taxa are presented in the following discussion that illustrates the range in rationale for ranking species as Special Concern.

Obovaria jacksoniana (Frierson 1912) - southern hickorynut. Distribution: Figure 22. STATUS: State – Special Concern and *Villosa arkansasensis* (Lea 1862) - Ouachita creekshell. Distribution: Figure 23. STATUS: State – Special Concern.

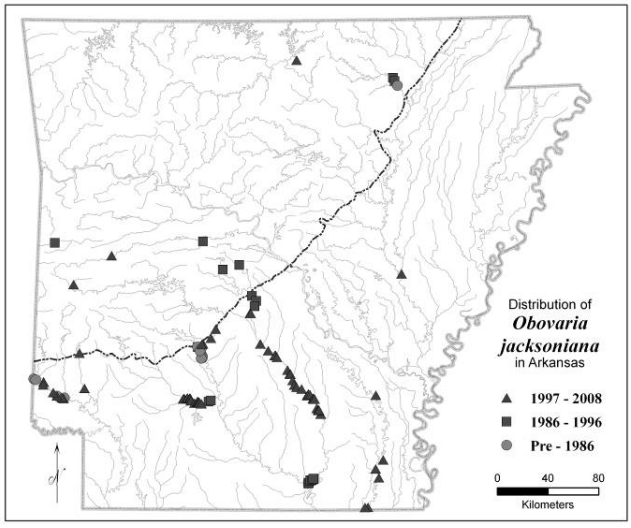

Figure 22. Distribution of *Obovaria jacksoniana*.

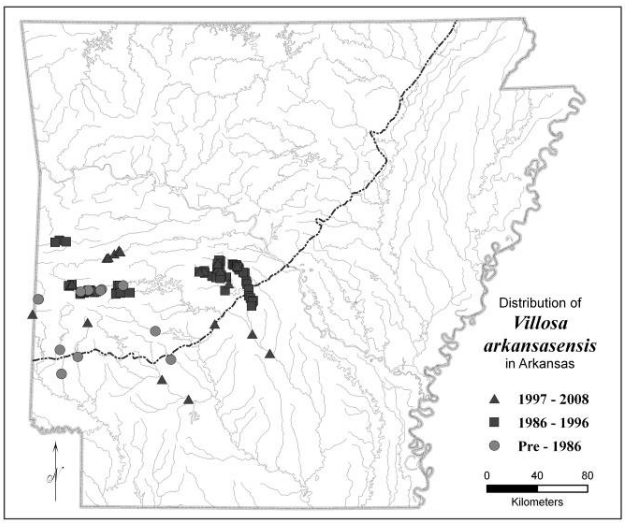

Figure 23. Distribution of *Villosa arkansasensis*.

Inoue (2009) investigated the taxonomy, conservation status, and life history attributes of *O. jacksoniana* in Arkansas. Although *O. jacksoniana* is morphologically distinct from *V. arkansasensis*, they are indistinguishable genetically using 3 mitochondrial (COI, ND1, and 16S) and 1 nuclear (28S) DNA genes. The data revealed phylogeographic structuring between Ouachita River and Red River drainage *O. jacksoniana* populations. Despite testing 18 potential host fish species, the host for *O. jacksoniana* was not definitively determined. Apart from Inoue (2009) life history sites, live *O. jacksoniana* were collected at 69 sites from 1997-2008, but only 117 specimens were found (x = 1.7/site).

Farris et al. (2005), Christian et al. (2006, 2007), and USFWS (2007b) present data regarding the current status of *V. arkansasensis*. Christian et al. (2007) reported relative numbers of *V. arkansensis* collected (n = 70) were significantly lower than Harris and Gordon (1988) (n = 98) in the Ouachita and Saline rivers. Christian et al. (2007) found 13 sites with fewer individuals, 3 sites having more individuals, and 1 site having the same number of live *V. arkansasensis* as Harris and Gordon (1988) sites. Christian et al. (2007) reported catch per unit effort below 0.5 *V. arkansasensis* per hour for most stations. Size frequency data of Ouachita River and Saline River *V. arkansasensis* indicate medium to large individual size ranges with no individuals smaller than 30 mm in length observed, suggesting limited recruitment. In 2006, the AGFC and USFWS sampled previously unsurveyed reaches in the Middle Fork Saline River and the Alum Fork Saline River resulting in 1 site on the Middle Fork with 1 live individual and 3 sites on the Alum Fork yielding 21 live *V. arkansasensis*. The USFWS (2007b) determined *V. arkansasensis* is declining in two Ouachita River basin streams and the Poteau River (13% of stream populations). Additionally, the species has been extirpated from 3 Ouachita River basin streams, thus 26% of Ouachita River basin stream populations are extirpated or declining. Population viability and trends for *V. arkansasensis* are unknown for 48% of historic stream populations.

Both *O. jacksoniana* and *V. arkansasensis* are relatively widespread, can be abundant in preferred habitat, but show trends toward population declines. Therefore, we have chosen to retain the State Special Concern status until the taxonomic relationship of *O. jacksoniana* and *V. arkansasensis* is resolved.

Ligumia recta (Lamarck 1819) - black sandshell. Distribution: Figure 24. STATUS: State - Special Concern.

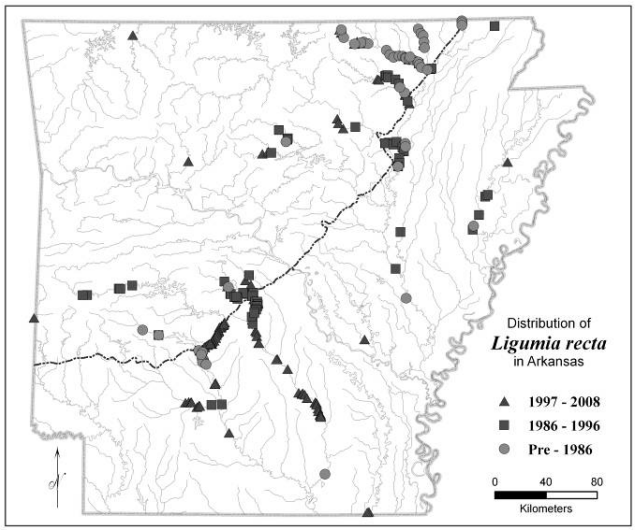

Figure 24. Distribution of *Ligumia recta*.

Although *L. recta* is widely distributed in the Ouachita, St. Francis, and White river drainages, it is never very abundant. The ANHC mussel database has records of *L. recta* collected between 1997-2008 for 104 sites; however, the number of live *L. recta* encountered totals 241 (x = 2.3 / site), and the maximum found at any site was 12. Due to concerns of low population numbers, we rank *L. recta* as a species of Special Concern in Arkansas.

Quadrula cylindrica cylindrica (Say 1817) - rabbitsfoot. Distribution: Figure 25. STATUS: State - Special Concern.

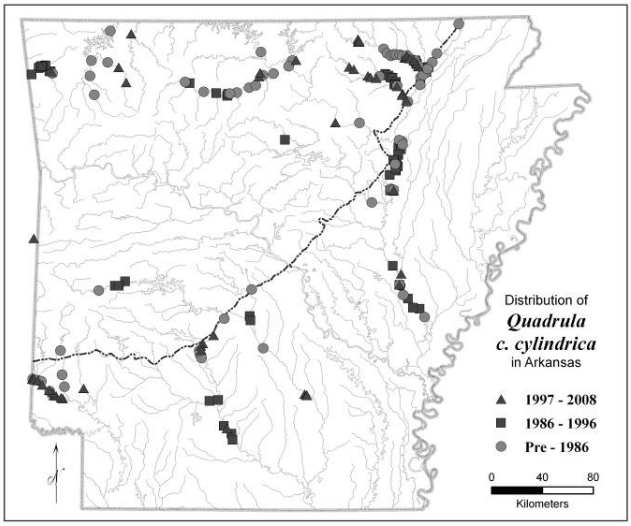

Figure 25. Distribution of *Quadrula c. cylindrica*.

The distribution of *Q. c. cylindrica* is similar to *L. recta*, in that it is relatively widespread but never exceptionally abundant. The ANHC mussel database has records of *Q. c. cylindrica* collected between 1997-2008 from 48 sites with a mean of 4.9 / site. The mean is skewed by large *Q. c. cylindrica* populations in the Spring and Black rivers.

Uniomerus declivis (Say 1831) - tapered pondhorn. Distribution: Figure 26. STATUS: State - Special Concern.

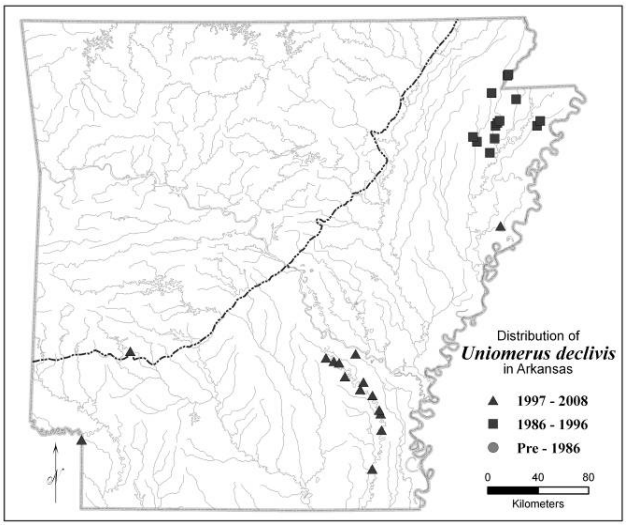

Figure 26. Distribution of *Uniomerus declivis*.

In Arkansas, *U. declivis* has been reported from the St. Francis, Ouachita, and Red river drainages below the Fall Line. Preferred habitat for *U. declivis* is apparently slow moving creeks and rivers with an abundance of silt and/or unconsolidated clay substrates. Brooks et al. (2008) found *U. declivis* to be relatively common in the upstream portion of Bayou Bartholomew. Additional locality records for *U. declivis* are expected as unsurveyed tributaries (lowland creeks) to the Arkansas, Ouachita, Saline, and Red rivers are explored.

Uniomerus tetralasmus (Say 1831) - pondhorn. Distribution: Figure 27. STATUS: State – Special Concern

In Arkansas, *U. tetralasmus* occurs primarily in the Delta and Western Gulf Coastal Plain (below the Fall Line); however, specimens have been recorded from the Interior Highlands where it has been found in the headwater tributaries of several rivers. We agree with Williams et al. (2008) that additional phylogenetic analyses are needed to delineate the morphological and distributional boundaries between *U. declivis* and *U. tetralasmus*.

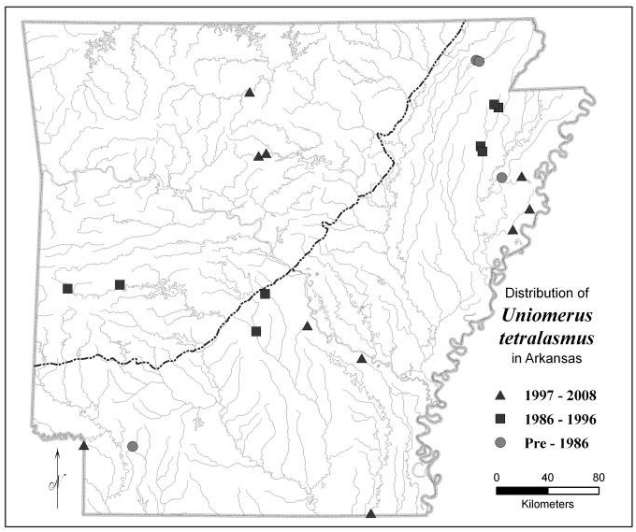

Figure 27. Distribution of *Uniomerus tetralasmus*.

Other Species

Pleurobema rubrum (Rafinesque 1820) - pyramid pigtoe. Distribution: Figure 28. STATUS: State - Currently Stable.

Species of *Pleurobema* are difficult to assign based on shell characters due to morphological variation among and between river systems. In the Saline and

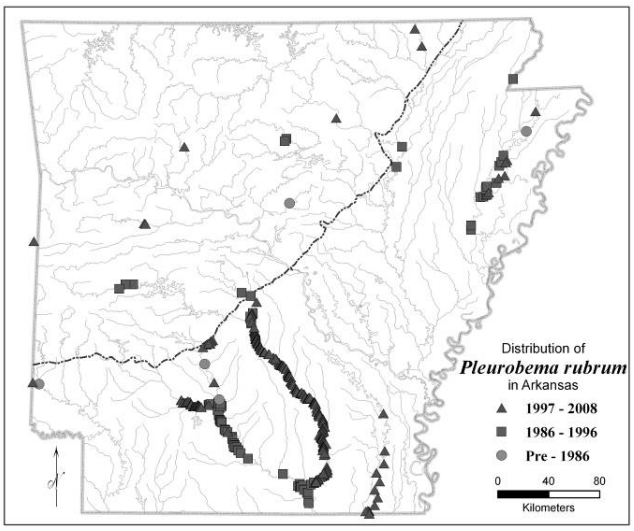

Figure 28. Distribution of *Pleurobema rubrum*.

Ouachita rivers, *P. rubrum* can be the dominant species in some mussel assemblages (Posey 1997, Davidson and Clem 2002, 2004). Recent studies have shown there may be at least two distinct taxonomic units residing within current concepts of *P. rubrum* (Campbell et al. 2005, Burdick and White 2007). Christian et al. (2008) noted phylogeographic structuring between *P. rubrum* from the Ouachita and St. Francis drainages that may represent species level variation. Until the taxonomic status of the Ouachita and St. Francis *P. rubrum* populations is resolved, this species is ranked Currently Stable.

Pleurobema riddellii (Lea 1861) - Louisiana pigtoe. Distribution: Little River, Saline and Ouachita rivers. STATUS: State - Uncertain.

Although Wheeler (1918) recognized *P. riddellii* from the Ouachita River (as *P. friersoni*), it has been lost in the maze of morphological forms and variation that is *Fusconaia* and *Pleurobema*. Vidrine (1993) and Howells et al. (1996) give the general distribution of *P. riddelli* as Western Gulf drainages and the southern portion of the Mississippi Interior Basin.

Posey (1997) did not separate *P. riddellii* from *Fusconaia flava* and *P. sintoxia*, which co-occur in the Ouachita River. Davidson and Clem (2002, 2004) included *P. riddellii* with *P. sintoxia* as their "*Fusconaia*/*Pleurobema* type" that comprised 9.8% and 7.5%, respectively of the total mussels collected during their Saline River surveys. Christian and Harris (2004) likely lumped *P. riddellii* with *F. flava* from the downstream reaches of the Little Missouri River.

Christian et al. (2008) recognized *P. riddellii* from the Ouachita and Saline rivers based on both molecular and morphological analyses. Subsequent molecular analyses also place the species in the Little River, and it is expected to occur in other Red River drainage streams (i.e. Cossatot and Saline rivers) as well. There appears to be phylogeographic structuring when comparing molecular data between *P. riddellii* from the Ouachita and Red River drainages (D. Hayes and K. Inoue, Arkansas State University, personal communication, 2009). We choose to assign a State Uncertain status to *P. riddellii* until more detailed analysis of its distribution and relative abundance can be completed.

Ptychobranchus occidentalis (Conrad 1836) - Ouachita kidneyshell. Distribution: Figure 29. STATUS: State - Currently Stable, and *Ptychobranchus* sp. cf *P. fasciolaris.*

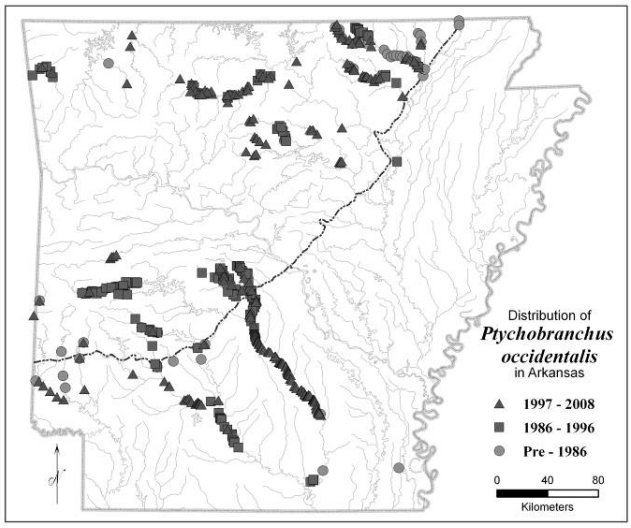

Figure 29. Distribution of *Ptychobranchus occidentalis*.

Harris et al. (1997) noted conchological differences in *Ptychobranchus* specimens from the White and St. Francis river drainages when compared with those from the Arkansas, Ouachita, and Red River drainages. Roe (2001, 2004) reported preliminary results of the genus *Ptychobranchus* phylogenetics that showed *P. occidentalis* from the Ouachita River drainage was sister to a large group containing *P. occidentalis* from the White and Arkansas river systems, + *P. fasciolaris*. The Ouachita drainage *P. occidentalis* were genetically distinct from other *P. occidentalis* populations with genetic differences

ranging from 1.5% to 2.0%. These differences were interpreted to mean that *P. occidentalis* and *P. fasciolaris* are only recently diverged. If in fact there are 2 separate species of *Ptychobranchus* in Arkansas, nomenclatural revision will be required because the type locality for *P. occidentalis* is the Current River (White River drainage), Arkansas (Roe 2004). For the time being, *P. occidentalis* (Ouachita and Red river drainages) and *P.* sp. cf. *P. fasciolaris* (White and Arkansas river drainages) will be considered separate taxonomic units for conservation management in Arkansas.

Quadrula apiculata (Say 1829) - southern mapleleaf. Distribution: Figure 30. STATUS: State - Currently Stable.

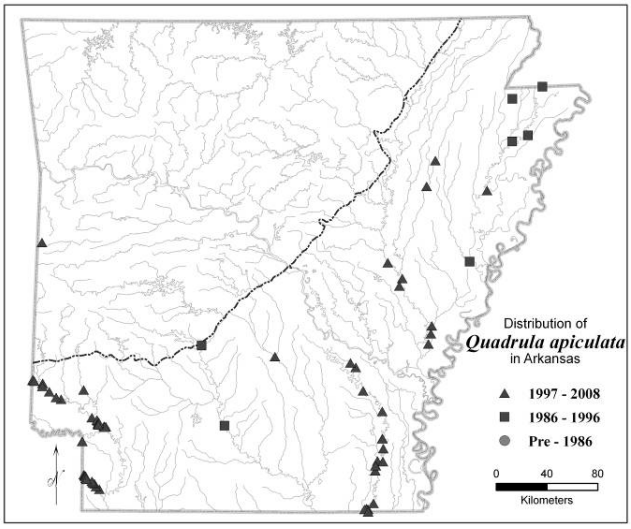

Figure 30. Distribution of *Quadrula apiculata*.

Harris et al. (1997) reported only 2 site occurrences for *Q. apiculata* in Arkansas. Subsequent molecular genetic studies coupled with morphological analyses redefined the level of morphological variation that encompasses *Q. apiculata* (Harris and Serb 2004). Surveys in the Little River (Seagraves 2006, URS 2007), White River (Harris and Christian 2000, and Bayou Bartholomew (Brooks et al. 2008) have shown *Q. apiculata* to be widespread and occasionally relatively abundant in rivers below the Fall Line.

Discussion

During the last 10+ years, more than 1800 rkm of Arkansas streams were surveyed to inventory mussel distribution and abundance. However, there are still relatively long segments of large stream systems with mussel faunas that are relatively unknown. Red River tributaries in southwest Arkansas such as the Cossatot River, Saline River, and Bayou Dorcheat have not been systematically surveyed. The potential for unknown populations of *A. wheeleri*, *M. hembeli*, and *Q. fragosa* in these streams makes them a high priority for survey efforts.

In southeastern Arkansas, the mussel fauna of Bayou Macon remains relatively unknown. The discovery of *Q. refulgens* in this highly-modified-for-agricultural-drainage Delta stream suggests that this habitat might continue to offer refuge to other rare Gulf Coast drainage fauna Of course, the Mississippi River remains the last great frontier for mussel survey efforts, as virtually nothing is known of mussel communities along its entire length of Arkansas' eastern border.

The mainstem Arkansas River mussel fauna is no longer a mystery, as reaches from Arkansas' eastern to western border have now been surveyed (Davidson 1997, Ecological Specialists Inc. 2005a). The mussel faunas of many southward draining Arkansas River tributaries including Frog Bayou, Mulberry River, Illinois Bayou, and Big Piney Creek have been inventoried; however, large segments of the Cadron Creek and Point Remove Creek remain unsurveyed. Many northward and eastward draining Arkansas River tributaries have not been systematically surveyed, including the downstream (big river) reaches of the Fourche LaFave and Petit Jean rivers, as well as the entire lengths of Little Maumelle River, Maumelle River, and Fourche Creek in central Arkansas. The potential for undiscovered populations of *C. aberti* and *L. leptodon* should make these streams a priority for survey efforts.

Mussel taxonomy and systematics has undergone a renaissance, due in large part to the development of new tools such as molecular genetic techniques and geometric morphometric applications for unveiling subtle yet significant differences between cryptic species within the framework of phylogenetics. The proliferation of taxonomic investigations has awoken *Q. mortoni* and *Q. nobilis* from the slumber of synonomy (Serb et al. 2003); however, their status in Arkansas is uncertain. Although *Cyprogenia aberti* was previously recognized as potentially harboring 2 species (Harris et al. 1997), the level of genetic differentiation unveiled by Serb (2006) and Serb and Barnhart (2008) could not be envisioned. Harris et al. (2004) detected phylogeographic structuring within

Arkansas *Villosa lienosa* that may represent species level divergence. Additional cryptic diversity almost undoubtedly exists in *Fusconaia* and *Pleurobema* (Christian et al. 2008), and the taxon currently recognized as *Toxolasma lividus* could be composed of multiple cryptic species (M.E. Gordon, personal communication, 2009). Variability in *Q. quadrula* shell morphology suggests that species limits need refinement to determine if cryptic diversity exists within that taxon. Linking the eastern Gulf Coast fauna with the Arkansas fauna by validating the presence of *Glebula rotundata*, *L. ornata*, and *Q. refulgens* in the state requires us to evaluate the presence of other species, specifically *Elliptio arca* (Conrad 1834), in the Ouachita River drainage. It is inevitable that future phylogeographic studies will unmask additional hidden diversity, and it would not be surprising for the Arkansas fauna to approach 100 species.

Much has been accomplished in the past 20 years in regards to locating and obtaining baseline community composition, relative abundance, and population structure data for significant mussel resources across the state. Now that baselines are established, it is time to begin a statewide monitoring program to establish trends for not only endangered and threatened mussels, but for mussels that are considered currently stable. We recommend establishment of long term monitoring sites across the state with established time intervals between sample events using quantitative methods that provide statistical power for comparison over time and sufficient biological data to evaluate successful recruitment and shifts in population structure (Christian and Harris 2005, Christian et al. 2005).

At this time, we choose to recognize 85 mussel taxa in Arkansas (see Appendix I), even though some of those have yet to be described or their nomenclature remains in a state of flux. It has become apparent that inclusion of 2 mussel species, *F. subrotunda* (I. Lea 1831) and *O. subrotunda* (Rafinesque 1820), as components of the Arkansas fauna (ANHC 2002, Anderson 2006,) is based on misidentifications. There are no museum voucher specimens or other evidence to confirm that they have ever occurred within Arkansas. *Fusconaia subrotunda* occurs in the Ohio River drainage (Cummings and Mayer 1992), is widespread in the Cumberland River drainage (Cicerello et al. 1991), and occurs throughout the Tennessee River drainage (Parmalee and Bogan 1998, Williams et al. 2008). *Obovaria subrotunda* is known from the parts of the Great Lakes Basin, the Ohio River drainage (Cummings and Mayer 1992), the Cumberland River drainage (Cicerello et al. 1991, Parmalee and Bogan 1998), and the Tennessee River drainage (Parmalee and Bogan 1998, Williams et al. 2008). Within the Arkansas mussel fauna, 19 species (22%) are considered Endangered, 5 species (6%) are ranked as Threatened, 20 species (24%) are of Special Concern, and unfortunately, 1 species has probably been extirpated. On par with the national average, ~53% of the Arkansas mussel fauna require management for some level of conservation concern.

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Appendix I. Unionoid mussels in Arkansas with a summary of conservation status rankings.

Species	Common Name	Nature Serve 2009	ANHC Rank	Harris et al. 1997	State Listing 2009
Actinonaias ligamentina (LaMarck 1819)	mucket	G5	S5	CS	CS
Alasmidonta marginata Say 1818	elktoe	G4	S3	CS	SC
Alasmidonta viridis (Rafinesque 1820)	slippershell mussel	G4G5	S1	E	E
Amblema plicata (Say 1817)	threeridge	G5	S5	CS	CS
Anodonta suborbiculata Say 1831	flat floater	G5	S3	SC	CS
Anodontoides ferussacianus (I. Lea 1834)	cylindrical papershell	G5	SU	NR	E
Arcidens confragosus (Say 1829)	rock pocketbook	G4	S3	CS	CS
Arkansia wheeleri Ortmann and Walker 1912	Ouachita rock pocketbook	G1	S1	E	E
Cumberlandia monodonta (Say 1829)	spectaclecase	G3	S1	E	E
Cyclonaias tuberculata (Rafinesque 1820)	purple wartyback	G5	S3?	CS	SC
Cyprogenia aberti (Conrad 1850)	western fanshell	G2G3Q	S2	SC	E
Cyprogenia sp. cf *C. aberti*	none	X	NR	NR	U
Cyprogenia sp. cf *C.stegaria*	none	X	NR	NR	U
Cyprogenia stegaria (Rafinesque 1820)	fanshell	G1Q	S1?	NR	E
Ellipsaria lineolata (Rafinesque 1820)	butterfly	G4	S3	CS	CS
Elliptio dilatata (Rafinesque 1820)	spike	G5	S4	CS	CS
Epioblasma florentina curtisii (Frierson and Utterback 1916)	Curtis pearlymussel	G1T1	S1	E	E
Epioblasma triquetra (Rafinesque 1820)	snuffbox	G3	S1	E	E
Epioblasma turgidula (I. Lea 1858)	turgid blossum	GX	SX	EX	EXT
Fusconaia ebena (I. Lea 1831)	ebonyshell	G4G5	S3S4	CS	CS
Fusconaia flava (Rafinesque 1820)	Wabash pigtoe	G5	S4	CS	CS
Fusconaia ozarkensis (Call 1887)	Ozark pigtoe	G3G4	S3	CS	SC
*Glebula rotundata (*Lamarck 1819)	round pearlshell	G4G5	SU	NR	E
Lampsilis abrupta (Say 1831)	pink mucket	G2	S2	T	T
Lampsilis cardium Rafinesque 1820	plain pocketbook	G5	S4	CS	CS
Lampsilis hydiana (I. Lea 1838)	Louisiana fatmucket	G4Q	S3	CS	CS
Lampsilis ornata (Conrad 1835)	southern pocketbook	G5	S1	U	E
Lampsilis powellii (I. Lea 1852)	Arkansas fatmucket	G2	S2	T	T
Lampsilis rafinesqueana Frierson 1927	Neosho mucket	G2	S1	T	E
Lampsilis r. reeveiana (I. Lea 1852)	Arkansas brokenray	G4T4	S3	CS	CS
Lampsilis satura (I. Lea 1852)	sandbank pocketbook	G2	S2	CS	SC
Lampsilis siliquoidea (Barnes 1823)	fatmucket	G5	S3	CS	SC
Lampsilis sp. A cf *L. hydiana*	Arkoma fatmucket	NR	S3?	NR	CS
Lampsilis sp. B cf *L. hydiana*	Red River fatmucket	NR	S2?	NR	T
Lampsilis streckeri Frierson 1927	speckled pocketbook	G1Q	S1	E	E
Lampsilis teres (Rafinesque 1820)	yellow sandshell	G5	S4	CS	CS
Lasmigona c. complanata (Barnes 1823)	white heelsplitter	G5	S3S4	CS	CS
Lasmigona costata (Rafinesque 1820)	flutedshell	G5	S3	CS	SC
Leptodea fragilis (Rafinesque 1820)	fragile papershell	G5	S4	CS	CS
Leptodea leptodon (Rafinesque 1820)	scaleshell	G1G2	S1	T	E
Ligumia recta (Lamarck 1819)	black sandshell	G5	S2	CS	SC
Ligumia subrostrata (Say 1831)	pondmussel	G5	S4	CS	CS

Species	Common Name	Nature Serve 2009	ANHC Rank	Harris et al. 1997	State Listing 2009
Margaritifera hembeli (Conrad 1838)	Louisiana pearlshell	G1	SH	NR	E
Megalonaias nervosa (Rafinesque 1820)	washboard	G5	S3S4	CS	CS
Obliquaria reflexa Rafinesque 1820	threehorn wartyback	G5	S4	CS	CS
Obovaria jacksoniana (Frierson 1912)	southern hickorynut	G2	S2	SC	SC
Obovaria olivaria (Rafinesque 1820)	hickorynut	G4	S3	CS	SC
Plectomerus dombeyanus (Valenciennes 1827)	bankclimber	G5	S4	CS	CS
Pleurobema cordatum (Rafinesque 1820)	Ohio pigtoe	G4	S2	CS	T
Pleurobema riddellii (Lea 1861)	Louisiana pigtoe	G1G2	S2?	NR	U
Pleurobema rubrum (Rafinesque 1820)	pyramid pigtoe	G2G3	S2	SC	CS
Pleurobema sintoxia (Rafinesque 1820)	round pigtoe	G4G5	S3	CS	CS
Potamilus alatus (Say 1817)	pink heelsplitter	G5	S1	E	E
Potamilus capax (Green 1832)	fat pocketbook	G1G2	S1	T	T
Potamilus ohiensis (Rafinesque 1820)	pink papershell	G5	S3S4	CS	CS
Potamilus purpuratus (Lamarck 1819)	bleufer	G5	S4	CS	CS
Ptychobranchus occidentalis (Conrad 1836)	Ouachita kidneyshell	G3G4	S3	CS	CS
Ptychobranchus sp. cf *P. fasciolaris*	none	X	NR	NR	CS
Pyganodon grandis (Say 1829)	giant floater	G5	S5	CS	CS
Quadrula apiculata (Say 1829)	southern mapleleaf	G5	S2	T	CS
Quadrula c. cylindrica (Say 1817)	rabbitsfoot	G3G4	S2	SC	SC
Quadrula fragosa (Conrad 1835)	winged mapleleaf	G1	S1	E	E
Quadrula metanevra (Rafinesque 1820)	monkeyface	G4	S3S4	CS	CS
Quadrula mortoni (Conrad 1836)	western pimpleback	G5T3Q	NR	NR	U
*Quadrula nobilis (*Conrad 1854)	Gulf mapleleaf	X	NR	NR	U
Quadrula nodulata (Rafinesque 1820)	wartyback	G4	S4	CS	CS
Quadrula p. pustulosa (I. Lea 1831)	pimpleback	G5	S5	CS	CS
Quadrula quadrula (Rafinesque 1820)	mapleleaf	G5	S5	CS	CS
Quadrula refulgens (I. Lea 1868)	purple pimpleback	G3G4	S1?	NR	E
Quadrula verrucosa (Rafinesque 1820)	pistolgrip	G4G5	S4	CS	CS
Simpsonaias ambigua (Say 1825)	salamander mussel	G3	S1	E	E
Strophitus undulatus (Say 1817)	creeper	G5	S3	CS	SC
Toxolasma lividus (Rafinesque 1831)	purple lilliput	G2	S2	SC	SC
Toxolasma parvus (Barnes 1823)	lilliput	G5	S4	CS	CS
Toxolasma texasiensis (I. Lea 1857)	Texas lillliput	G4	S3	CS	SC
Truncilla donaciformis (I. Lea 1828)	fawnsfoot	G5	S3	CS	SC
Truncilla truncata Rafinesque 1820	deertoe	G5	S4	CS	CS
Uniomerus declivis (Say 1831)	tapered pondhorn	G5Q	S1	CS	SC
Uniomerus tetralasmus (Say 1831)	pondhorn	G5	S2	CS	SC
Utterbackia imbecillis (Say 1829)	paper pondshell	G5	S3S4	CS	CS
Venustaconcha ellipsiformis (Conrad 1836)	ellipse	G4	S1	CS	E
Venustaconcha pleasii (Marsh 1891)	bleedingtooth mussel	G3G4	S3	CS	SC
Villosa arkansasensis (I. Lea 1862)	Ouachita creekshell	G2	S2	SC	SC
Villosa iris (I. Lea 1829)	rainbow	G5Q	S2S3	CS	SC
Villosa lienosa (Conrad 1834)	little spectaclecase	G5	S3	CS	SC