Speckled Pocketbook
(Lampsilis streckeri Frierson 1927*)*

5-Year Review:
Summary and Evaluation

Photo Courtesy: Chris Davidson, US Fish and Wildlife Service

U.S. Fish and Wildlife Service
Arkansas Ecological Services Field Office
Southeast Region

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†Please see Addendum 1 at the end of this, our 2015 5-year review, document. The Addendum provides the limited new information we have gathered for our third 5-year review (dated September 2021) for this endangered freshwater mussel that was initiated in the Federal Register (June 23, 2021, 86 FR 32965) and the analysis we provide to explain the basis for continuing to recommend no status change for this species.

5-YEAR REVIEW
Speckled Pocketbook (*Lampsilis streckeri* Frierson 1927)

I. GENERAL INFORMATION

A. Methodology used to complete review

We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period on March 25, 2014 (79 FR 16366). During the comment period, we did not receive any additional new information about Speckled Pocketbook from the public. Additional information used in this report was gathered from unpublished data collected by the Service's Arkansas Ecological Services Field Office (AES) and Arkansas Game and Fish Commission (AGFC) and unpublished reports in AES files. This review was completed by the lead recovery biologist in the AES.

A draft of this 5-year review was circulated to three persons for peer review. Comments and suggestions regarding the review were received from Bill Posey, Arkansas Game and Fish Commission; Josh Seagraves, Arkansas Highway and Transportation Department; and Dr. John Harris, Arkansas State University. No part of the review was contracted to an outside party. Recommendations are a result of thoroughly reviewing the best available information on this mussel and based in the author's expertise as one of the leading experts on this species.

B. Reviewers

Lead Region: Southeast Region: Kelly Bibb, (404) 679-7132

Lead Field Office: AES – Chris Davidson, (501) 513-4481

C. Background

1. **Federal Register Notice initiating this review:** (79 FR 16366), March 25, 2014.

2. **Species Status:** Stable. Monitoring data obtained by AES and AGFC from 2008 – 2009 indicates presence of individuals at a greater number of localities than previously known. Number of individuals at previously documented sites is equal to or greater than previous surveys.

3. **Listing History**
   Original Listing

   FR notice: 54 FR 8339
   Date listed: February 28, 1989
   Entity listed: Species
   Classification: Endangered

4. **Associated rulemakings:** None

5. **Review History**
   5-Year Reviews
   U.S. Fish and Wildlife Service. 2007. Speckled Pocketbook 5-year review: summary and evaluation. Conway, AR. 16 pp.

   5-year review November 6, 1991 (56 FR 56882) – In this review, different species were simultaneously evaluated with no in-depth assessment of the five factors, threats, etc. as they pertained to the different species' recovery. In particular, no changes in status were proposed for this mussel.

   Status Reviews

   Harris, J.L., W.R. Posey II, C.L. Davidson, J.L. Farris, S.R. Oetker, J.N. Stoeckel, B.G. Crump, M.S. Barnett, H.C. Martin, M.W. Matthews, J.H. Seagraves, N.J. Wentz, R. Winterringer, C. Osborne, and A.D. Christian. 2010a. Unionida (Mollusca: Margaritiferidae, Unionidae) in Arkansas, Third Status Review. Journal of the Arkansas Academy of Science 63 (2009):50-86.

   Harris, J. L., P. J. Rust, A. C. Christian, W. R. Posey II, C. L. Davidson and G. L. Harp. 1998. Revised status of rare and endangered Unionacea (Mollusca: Margaritiferidae, Unionidae) in Arkansas. Journal of the Arkansas Academy of Science 51 (1997):66-89.

   Clarke, A. E. 1987. Status survey of *Lampsilis streckeri* Frierson (1927) and *Arcidens wheeleri* (Ortmann and Walker 1912). A report to the U. S. Fish and Wildlife Service. 24pp. plus field notes.

6. **Species' Recovery Priority Number at start of review (48 FR 43098)**: 8. This number reflects a moderate degree of threat and a high recovery potential.

7. **Recovery Plan:**
   Name of plan: Speckled Pocketbook Mussel (*Lampsilis streckeri*) Recovery Plan.
   Date issued: January 2, 1992

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy: The DPS policy only applies to vertebrate species. Since the Speckled Pocketbook is an invertebrate, the DPS policy does not apply.

B. Recovery Plan and Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes.

2. **Adequacy of recovery criteria**.

   a. **Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?** No.

      The objective of this plan is to reclassify the Speckled Pocketbook from endangered to threatened status. The Speckled Pocketbook may be reclassified when:

      (1) four additional populations are discovered or reestablished,

      (2) all five populations are viable and the habitat fully protected, and

      (3) viable population levels are maintained for a period of at least 20 years.

      The recovery criteria for reclassification are stringent considering only five stream populations are known from historical literature and the species is endemic to the Little Red River watershed in Arkansas. The main stem Little Red River population has been permanently lost due to inundation in Greers Ferry Reservoir and cold water releases in its tailwaters. The Middle Fork Little Red River was believed to be the only remaining stream population at listing (Service 1989) and as recently as 2003. However, populations persist in the four forks of the Little Red River and Big Creek, a tributary to the Little Red River downstream of Greers Ferry Reservoir. Given this information, no additional populations could be added to develop delisting criteria.

      The definition of a viable population in the recovery plan does not provide a measure for reproductive capability other than to state it must "…*sustain itself without immigration of individuals from other populations*." Mussel populations generally are considered persistent and viable if there is demonstrated and sustainable natural reproduction and recruitment as evident by multiple age classes of individuals, including naturally recruited juveniles, and recruitment rates exceeding mortality rates for a period of five consecutive years or three consecutive surveys at three to five year intervals. Since three of five stream populations are fragmented by Greers Ferry Reservoir, immigration of individuals from other populations is unlikely to occur. Observations of gravid females and recruitment of Speckled Pocketbook young into the population has only been documented in two of the four forks. However, it is unknown at this time whether recruitment rates exceed mortality rates in these populations.

      The recovery plan is a departure from the normal recovery process to expect 100 percent recovery of stream populations for reclassification. Revising the recovery criteria to better address the five listing factors is required so measurable recovery criteria can be developed and applied to downlist and delist this species. Delisting also may not warrant recovery in 100 percent of populations.

   b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)?** No.

3. List the recovery tasks as they appear in the recovery plan, and discuss how each task has or has not been achieved?

The 1992 Recovery Plan (USFWS 1992) for Speckled Pocketbook includes the following recovery tasks. Each recovery task and extent to which it has or has not been met is discussed below. New information is available for Tasks 1.1, 1.2, 3.1, 3.2 and 4.2 since the previous five year review.

Task 1.1 Conduct population surveys

A comprehensive status survey for Speckled Pocketbook in Big Creek is still required to establish baseline information on distribution and abundance. A 1992 status survey provides baseline data on distribution and abundance of Speckled Pocketbook in the lower reaches of the South, Middle, and Archey forks Little Red River (Harris 1992). The four forks of the Little Red River were comprehensively surveyed in 2004 – 2005 and 2008 – 2009 (C. Davidson pers. comm.; ANHC database 2014). Long-term monitoring sites were established during the 2008 – 2009 assessment and will be monitored at a seven year interval. A summary of additional surveys follows.

1991 – Harris, J. L. – Conducts a survey for *Lampsilis streckeri* in the Middle Fork Little Red River at the proposed NOARK pipeline crossing prepared for ENSR Consulting and Engineering.

1993 – Harris, J. L. – Habitat characterization and species associates of the Speckled Pocketbook (*Lampsilis streckeri*) in the Middle Fork Little Red River, Arkansas.

2003 – Winterringer, R. – Population dynamics and reproductive patterns of the federally endangered freshwater mussel, *Lampsilis streckeri*.

2005 – AES – Survey for Speckled Pocketbook in a selected reach of Big Creek, a northern tributary of the Little Red River below Greers Ferry Reservoir.

2006 – AES and AGFC – Survey for Speckled Pocketbook in Middle Fork Little Red River from Little Red Creek confluence to Winterringer (2003) upstream Speckled Pocketbook occurrence.

Task 1.2 Use legislation to protect habitat

Sources of nonpoint source pollution in the Little Red River watershed include a variety of land uses that allow bare earth to enter streams (e.g., timber harvesting, natural gas development, unpaved roads, etc.). Current federal and state laws do not adequately protect Speckled Pocketbook habitat from nonpoint source pollution, as the laws to prevent sediment and other contaminants from entering waterways are poorly enforced. Best management practices (BMPs) for erosion control are often recommended or required through industry certifications or state and federal permits. Compliance, monitoring, and enforcement of these recommendations are often poorly implemented, but implementation is improving in the upper Little Red River watershed.

The Arkansas Department of Environmental Quality has designated the Archey, Middle, South, and Devils forks Little Red River as ecologically sensitive waterbodies. This designation provides for more stringent water quality criteria and restricts certain activities that may degrade water quality or habitat (*e.g.,* instream gravel mining). However, short-term activity authorizations to exceed existing water quality protections for up to 30 days for construction activities are routinely issued to permit applicants. Therefore, existing regulatory mechanisms have been insufficient to significantly reduce and remove threats to Speckled Pocketbook.

Task 2.1 Characterize habitat

Preferred habitat types for adult Speckled Pocketbook have been described by Harris (1993) and Winterringer (2003).

Task 2.2 Determine associate species

Several surveys (refer to Task 1.1) have documented associate species and composition in the upper Little Red River watershed and Big Creek. A population dynamics (refer to Task 1.1) study was completed by Winterringer in 2003 that provides mussel community abundance and composition for the Middle Fork Little Red River.

Task 2.3 Develop life history data

Winterringer (2003) determined reproductive patterns, including fish host identification and refined artificial propagation techniques, for Speckled Pocketbook.

Harris *et al.* (2004) investigated the limits and phylogeography of Lampsilinae in Arkansas with emphasis on species of *Lampsilis*. Speckled Pocketbook specimens formed a well supported monophyletic group, within the *Lampsilis reeveiana* complex, that is significantly divergent from *L. reeveiana*. This finding was consistent with the Speckled Pocketbook's current taxonomic status as a distinct species.

Harris *et al.* (2010b) further explored genetic relationships between Speckled Pocketbook and *L. reeveiana*. They suggested that *L. reeveiana* and Speckled Pocketbook may co-occur in the Little Red River basin. However, there is no reason to assume that *L. reeveiana* like individuals/populations could maintain genetic isolation among a population that is overwhelmingly Speckled Pocketbook. Speckled Pocketbook is a relatively recent divergence from *L. reeveiana* and the divergence is shallow. Therefore, some Speckled Pocketbook specimens may come out more closely aligned with *L. reeveiana* in some analyses, but they are still Speckled Pocketbook (Harris 2015 pers. comm.).

Task 3.1 Develop plan to restore historic habitat

The recovery plan identified the need to restore habitat in the lower Archey and South forks Little Red River (3.5 river miles) that once supported Speckled Pocketbook but currently does not due to channel modifications for flood control in the mid – 1980s.

A coalition of partners began developing a plan in 2008 to restore this 3.5 river mile reach. Restoration efforts were completed in 2014. The endemic Yellowcheek Darter, which also was extirpated from this river reach, was collected within the restored reach in October 2014.

A programmatic Safe Harbor Agreement (SHA) for the upper Little Red River watershed was signed by the AES, Arkansas Game and Fish Commission, Natural Resources Conservation Service, and The Nature Conservancy in 2007. To date, 12,195 acres have been enrolled under the programmatic agreement and approximately 49,000 acres have draft property owner management agreements (POMAs). Total perennial and intermittent stream length protected via signed (POMAs) is 47.7 river miles. Conservation measures implemented on enrolled properties in the South and Middle Forks have resulted in a reduction of approximately 1,400 tons of sediment/year from reaching waterways (Service 2013).

The programmatic agreement was amended in 2014 to include additional federally protected and aquatic species of greatest conservation need. The associated permits are currently pending review by the Service and should be issued in 2015. While enrollment of properties has been delayed for two years due to requirements to amend the permits, enrollment is expected to begin again in 2015.

Other efforts to restore historical habitat include an unpaved roads inventory, unpaved road workshops in the watershed, a statewide initiative to develop an unpaved roads program, development of BMPs for natural gas development activities, plans to remove two fish passage barriers on the Middle Fork, and the ECH_2O (Energy Conserving Water) initiative started by Southwestern Energy with a goal, among others, to reforest 300 acres/year of pastureland in the watershed.

Task 3.2 Develop plan for reestablishing mussel populations
Significant progress has been achieved during the past six years in restoring and improving historical and occupied habitat for Speckled Pocketbook. Propagation techniques have been developed for Speckled Pocketbook, but no plan to reestablish or augment populations exists or is planned at this time. It is the opinion of species experts that distribution and abundance is sufficient to sustain extant populations and at current levels should allow for population expansion into suitable habitat as habitat quality continues to improve.

Task 3.3 Implement plan to restore historic habitat
Refer to Task 3.1.

Task 3.4 Implement plan to reestablish populations in historical habitat
Refer to Task 3.2.

Task 4.1 Determine minimum population levels
Refer to Task 3.2.

Task 4.2 Develop plan to monitor populations
Long-term monitoring sites (N = 35) were established in 2008 – 2009 for the four forks of the Little Red River. Sites will be monitored at seven year intervals. Due to limited access and the remoteness of Big Creek, a monitoring plan has not been established yet.

Task 4.3 Implement monitoring plan
Refer to Task 4.2.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Spatial distribution, abundance and population trends

The current distribution for Speckled Pocketbook is unchanged since the Service's (2007) previous five year review. It is restricted to the Middle Fork Little Red River from the influence of Greers Ferry Reservoir upstream to the confluence of Little Red Creek (63 river miles (rmi)), the South Fork Little Red River extending from 0.5 rmi downstream of Arkansas Highway 95 upstream to near the western boundary of Gulf Mountain Wildlife Management Area and the Ozark National Forest (15 rmi), Archey Fork Little Red River from approximately one rmi upstream of Arkansas Highway 65 to the confluence of Castleberry Creek (16 rmi), lower Turkey Creek (2 rmi), and Beech Fork (11rmi; Figure 1). The known range of Speckled Pocketbook in Big Creek includes the reach from Tylar Road to the western (also most downstream) boundary of Big Creek Natural Area (17 rmi; Figure 1).

All extant populations continue to appear stable. Based on 2008 – 2009 sampling at long-term monitoring sites, 59 individuals were collected in the South Fork, 34 individuals in the Archey Fork, 127 individuals in the Middle Fork, and 12 individuals in the Devils Fork complex (Turkey Creek and Beech Fork). Newly established long-term monitoring sites are expected to contribute to a better understanding of population trends. Populations in Archey and Middle forks have documented reproduction and recruitment, but natural recruitment rates and mortality rates are unknown.

b. Demographic characteristics

Winterringer (2003) analyzed 49 Speckled Pocketbook individuals from the Middle Fork for sex, size, and gravidity status. Sex ratio was near 1:1 (23 females, 26 males). Combining 145 individuals collected since Winterringer's (2003) sampling in 2001, sex ratios range from 1:1 – 1:1.5 for the Middle Fork (76 females, 118 males), Archey Fork (13 females, 18 males), South Fork (26 females, 27 males), and Devils Fork complex (5 females, 7 males). Sex ratios were not reported for Big Creek collection sites in 2005.

Winterringer (2003) reported age structure for the Middle Fork of five to 11 year old individuals. Several 1 year old juveniles were collected from Archey Fork in

2005 (C. Davidson, pers. comm.). Mean lengths for Speckled Pocketbook in the Middle, South, Archey, and Devils forks are 62.9 (SD = 14.3), 66.3 (SD = 8.7), 73.1 (SD = 8.4), and 63.2 mm (SD = 10.1), respectively (Figures 2 – 5). Measurement data were not reported for Big Creek collection sites in 2005.

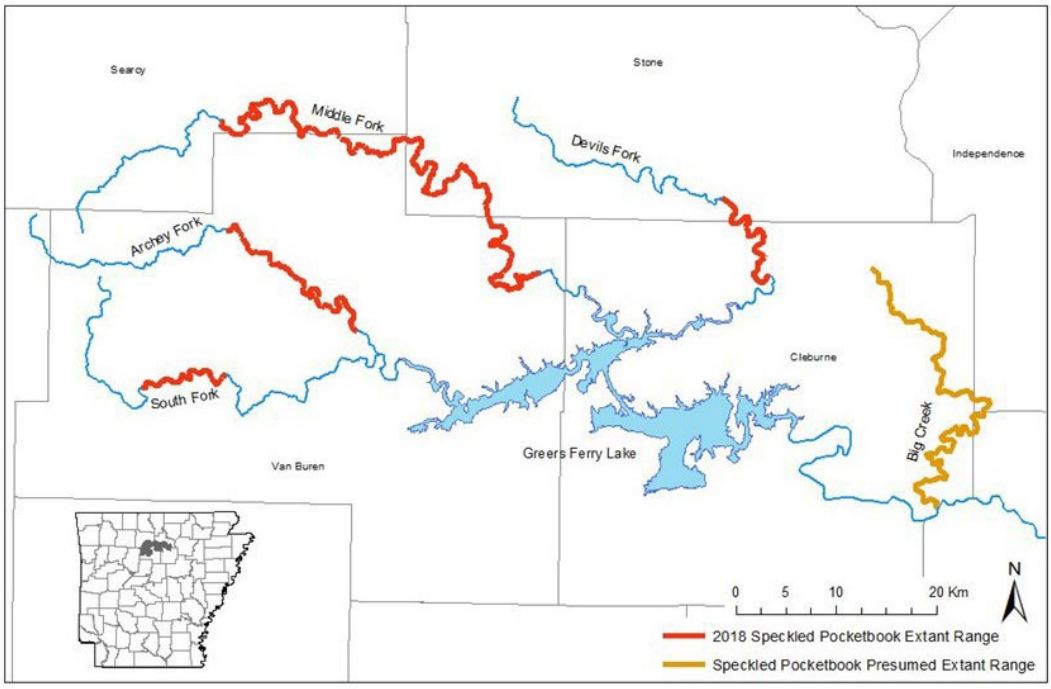

Figure 1. Distribution of Speckled Pocketbook in the Middle, South, Archey, and Devils Forks Little Red River.

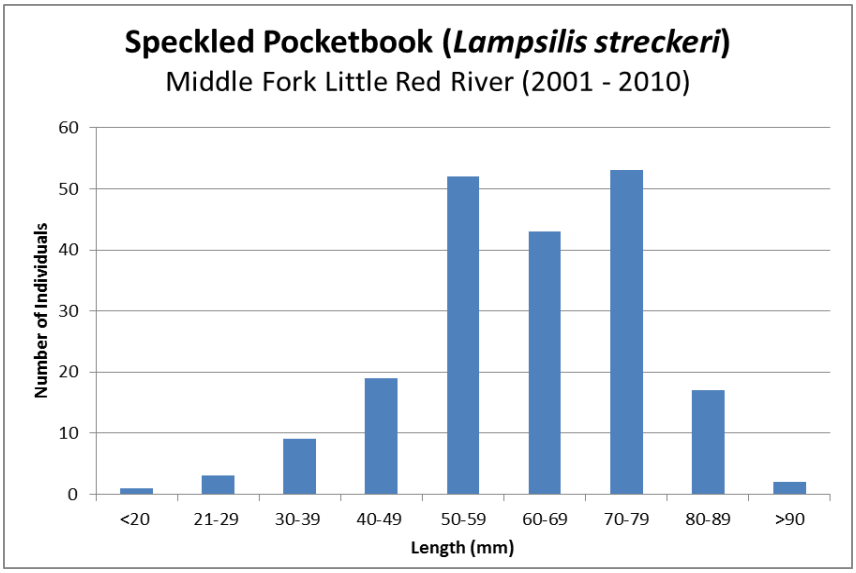

Figure 2. Length frequencies for Speckled Pocketbook collected from Middle Fork Little Red River, 2001 – 2010 (Winterringer 2003; C. Davidson, pers. comm.).

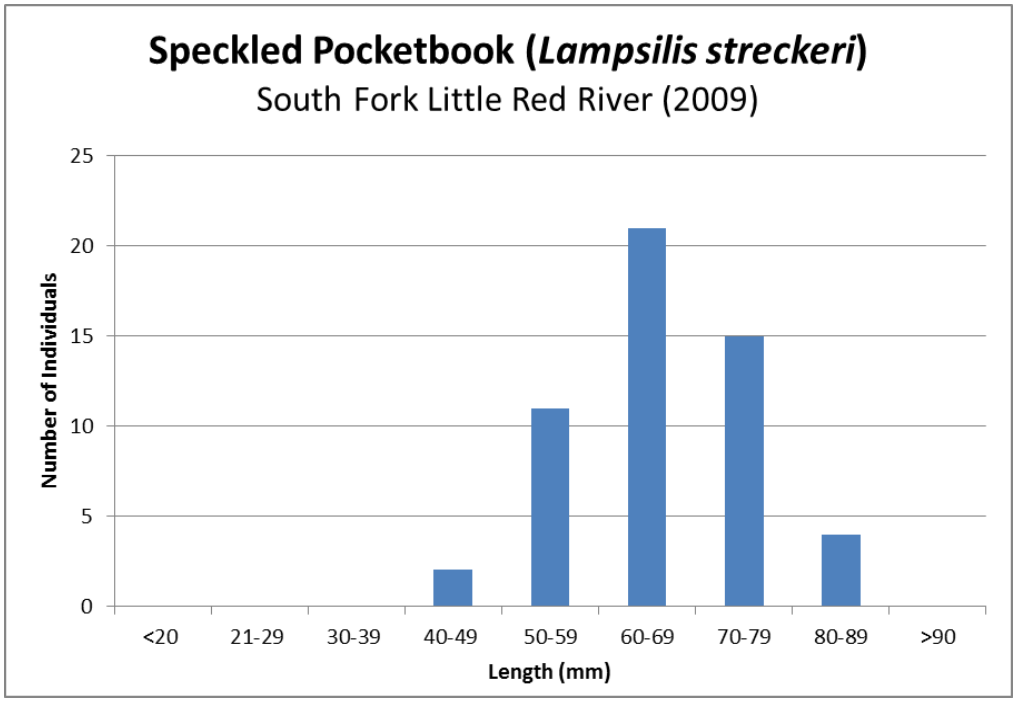

Figure 3. Length frequencies for Speckled Pocketbook collected from the South Fork Little Red River in 2009 (C. Davidson, pers. comm.).

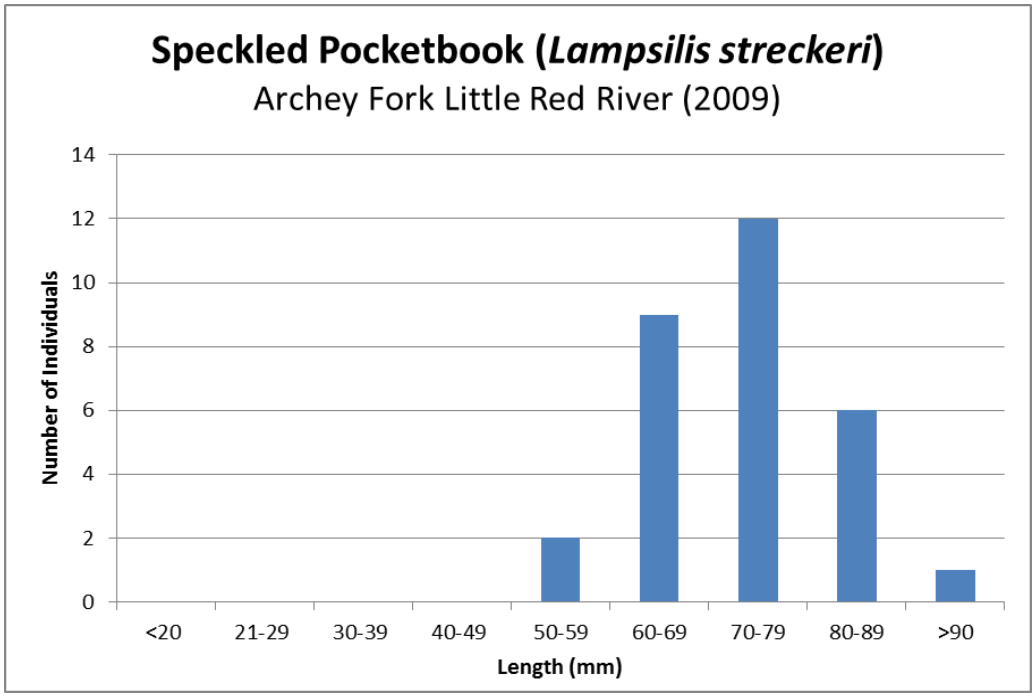

Figure 4. Length frequencies for Speckled Pocketbook collected from the Archey Fork Little Red River in 2009 (C. Davidson, pers. comm.).

The reproductive cycle of the Speckled Pocketbook is similar to other native freshwater mussels. Males release sperm into the water column. The sperm are then taken in by the females through their siphons during feeding and respiration. The

females retain the fertilized eggs in their gill marsupium until the larvae (glochidia) fully develop. The gill marsupium, which is used as a lure to mimic host fish prey, is attacked by a potential fish host, the female releases the larvae which then infest the fish, but will only transform to juveniles if it is a suitable host.

Gravid females have been observed from June – August in the Archey, Middle, and South Forks (Davidson and Wine 2004; Winterringer 2003; C. Davidson pers. comm.). Females have been observed releasing glochidia in February. Winterringer (2003) tested 22 fish species for their potential as suitable host. Larvae successfully transformed on sunfishes (Centrarchidae), with greatest success occurring with the green sunfish (*Lepomis cyanellus*; Table 1).

c. Habitat

There is no new information on habitat suitability for the Speckled Pocketbook. Suitable habitat occurs in pools and runs with small to large boulders which have some accumulation of sand/gravel. Individuals are typically located in crevices between boulders or underneath perched boulders (Harris 1993; Winterringer 2003; C. Davidson pers. comm.).

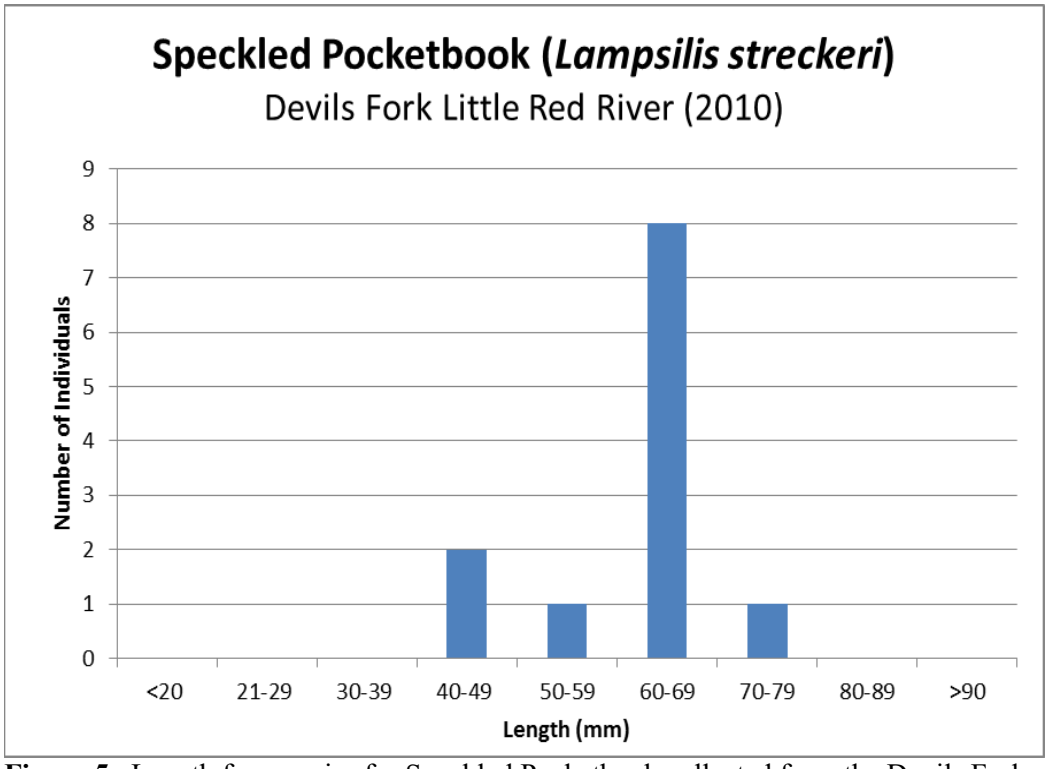

Figure 5. Length frequencies for Speckled Pocketbook collected from the Devils Fork (Turkey Creek and Beech Fork) Little Red River in 2010 (Service unpubl. data).

Table 1. Suitable fish hosts for the Speckled Pocketbook (Winterringer 2003).

Scientific Name	Common Name	First Trial	Second Trial	Transformation Rate (%)
Ambloplites ariommus	Shadow Bass	23	NT	0.9
Lepomis cyanellus	Green Sunfish	195	692	36.5
Lepomis macrochirus	Bluegill	341	NT	14.0
Lepomis gulosus	Warmouth	417	33	18.5
Lepomis megalotis	Longear Sunfish	466	25	20.2
Micropterus dolomieu	Smallmouth Bass	0	47	1.9
Micropterus punctulatus	Spotted Bass	27	167	8.0
Total Glochidia		1,469	964	100.0
NT = Not tested				

2. Five Factor Analysis (threats)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Existing threats include sediment and other contaminants derived from a variety of land use practices (*i.e.,* nonpoint source pollutants) and water consumption for fracking natural gas wells (primarily in the South Fork and Big Creek watersheds). Natural gas infrastructure development has subsided substantially since circa 2012. It appears unlikely, at this time, that substantial development of mineral resources (*i.e.*, natural gas) will occur in the upper South Fork, mid to upper Middle Fork, Archey Fork, and upper Devils Fork watersheds due to insufficient quantities of natural gas for profitability. While threats posed by natural gas development in the watershed have subsided, sediment and other chemical contaminants derived from gravel and rock mining, agricultural practices, and dirt and gravel road maintenance and construction appear to continue degrading suitable Speckled Pocketbook habitat.

A major threat at the time of listing was channelization of the lower Archey and South forks. With completion of the Archey Fork restoration project in 2014, this threat has been alleviated and suitable habitat for recolonization is present. The construction of Greers Ferry Reservoir resulted in the permanent loss of habitat and isolation of populations (Middle and Devils forks, Big Creek) due to inundation and cold tailwater releases downstream of the dam. Information on gene flow between populations and effective population size is lacking at this time. Fragmentation and isolation of small populations, particularly in Big Creek and the Devils Fork complex, may play a magnified role in population extirpation associated with stochastic events.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

There is no evidence to suggest that overutilization is a threat.

c. Disease or predation:

Muskrats and turtles are known to prey on Speckled Pocketbook, but predation is not considered a substantive threat at this time. We also have no evidence of disease in Speckled Pocketbook.

d. Inadequacy of existing regulatory mechanisms:
Regulatory mechanisms (*e.g.*, Clean Water Act [CWA] and ADEQ Regulation 2) are in place to protect water quality and habitat for Speckled Pocketbook. However, these regulatory mechanisms remain largely ineffective due to permitting practices that allow permittees to exceed water quality standards for 30 days (*i.e.*, ADEQ short-term activity authorization; refer to Task 1.2 for additional information). Despite some reductions in point source discharges, adequate protection may not be provided by the CWA for filter feeding animals, such as Speckled Pocketbook, that can be affected by extremely low levels of contaminants. Speckled Pocketbook populations in the Middle Fork and South Fork Little Red River may be subjected to pervasive, albeit subtle, effects of chronic, low-level contamination that is ubiquitous in the upper Little Red River watershed. However, there is no specific information known about the sensitivity of Speckled Pocketbook to common point source pollutants from industrial and municipal effluents. Because there is very little known about water quality parameters necessary to fully protect Speckled Pocketbook, it is difficult to determine whether the CWA is adequately addressing threats to Speckled Pocketbook.

e. Other natural or manmade factors affecting its continued existence:
Alterations in stream temperature regimes associated with channel widening, riparian tree canopy removal, and climate change may affect Speckled Pocketbook biological processes. Exact critical thermal limits for survival and normal functioning of Speckled Pocketbook are unknown. However, high water temperatures can reduce dissolved oxygen concentrations, which slows growth, reduces glycogen stores, impairs respiration, and may inhibit reproduction of mussels (Fuller 1974). Low temperatures also may significantly delay or prevent metamorphosis (Watters and O'Dee 1999). Altered thermal regimes may shorten the period of glochidial encystment, reduce righting speed (various reflexes that tend to bring the body into normal position in space and resist forces acting to displace it out of normal position), increase oxygen consumption, and slow burrowing and movement responses (Fuller 1974; Bartsch *et al.* 2000; Watters *et al.* 2001; Schwalb and Pusch 2007). Several studies have documented the influence of temperature on the timing aspects of mussel reproduction (Gray *et al.* 2002; Allen *et al.* 2007; Steingraeber *et al.* 2007). Peak glochidial releases are associated with water temperature thresholds that can be thermal minimums or maximums, depending on the species (Watters and O'Dee 2000).

Cumulative Effects of Threats
The life-history traits and habitat requirements of Speckled Pocketbook, and other freshwater mussels in general, make them extremely susceptible to environmental change. Unlike other aquatic organisms (*e.g.*, aquatic insects and fish), mussels

have limited refugia from stream disturbances (*e.g.*, droughts, sedimentation, chemical contaminants). Mechanisms leading to Speckled Pocketbook imperilment range from local (*e.g.*, riparian clearing, chemical contaminants, etc.), to regional influences (*e.g.*, altered flow regimes, population isolation, etc.), to potentially global climate change. The synergistic (interaction of two or more components) effects of threats are often complex in aquatic environments, making it difficult to predict changes in mussel and fish host(s) distribution, abundance, and habitat availability that may result from these effects. While these stressors may act in isolation, it is more probable that many stressors are acting simultaneously (or in combination) (Galbraith *et al.* 2010) on Speckled Pocketbook populations.

3. Conservation Measures

There is new information regarding implementation of conservation measures that benefit the Speckled Pocketbook.

A rangewide programmatic SHA was signed in 2007 by AES, AGFC, NRCS, and TNC. An amendment to the agreement is currently being processed by the Southeast Regional Office and is expected to be finalized in 2015. The amendment does not affect currently enrolled properties or future conservation measures implemented for Speckled Pocketbook. It adds two species to the SHA and 19 species of greatest conservation need to the candidate conservation agreement with assurances, all which have similar conservation needs as the Speckled Pocketbook. Service (2013) provides a detailed status report (2007 – 2012) of current enrolled properties and conservation measures implemented on enrolled properties under the SHA (also refer to Section II.B.3, Task 3.1).

Section II.B.3 provides a summary of conservation measures implemented for Speckled Pocketbook. Additionally in 2014, TNC acquired approximately 1,000 acres adjacent to the Archey Fork. This land acquisition perpetually protects approximately 2.5 river miles of the Archey Fork that is currently inhabited by Speckled Pocketbook. Pastureland on TNC's Archey Fork Preserve was reforested in partnership with Southwestern Energy's ECH$_2$O program.

D. Synthesis

At the time of listing, the only known population of Speckled Pocketbook was in the Middle Fork from the confluence of Meadow Creek downstream to near Shirley (approximately 10 rmi). Surveys in recent years have expanded the distribution of extant populations of Speckled Pocketbook to include the Middle Fork extending upstream of the Meadow Creek confluence to the confluence of Little Red Creek (an increase of 53 rmi). Extant populations also have been discovered in 14 rmi of the South Fork, 16 rmi of Archey Fork, two rmi of Turkey Fork, 11 rmi of Beech Fork, and ten rmi of Big Creek. Collectively, current extant populations occupy 102 rmi more than at the time of listing and four (Turkey and Beech Forks are considered one population) additional extant populations are known.

Characteristics of population demographics (*e.g.* suitable habitat, male to female sex ratio, etc.) are better understood now than at the time of listing. Primary and secondary suitable host fish have been identified and successful propagation techniques have been developed for the Speckled Pocketbook. These techniques will be extremely valuable in recovery efforts, should the need to conduct population augmentations or reintroductions arise. Additionally, phylogenetic analysis of the *Lampsilis* species in Arkansas support taxonomic status of the Speckled Pocketbook. Information on size structure of Speckled Pocketbook populations is better understood. However, the age structure, gene flow between populations, effective population size, and status of host fish are lacking at this time. These are important population biology issues that need to be determined in order to ensure the continued existence of Speckled Pocketbook.

The threat of natural gas development activities in the Fayetteville Shale poses an imminent threat (*e.g.* water quality and quantity and habitat fragmentation) to the species, albeit diminished now that most of the infrastructure is in place to access and transport natural gas out of the region. The Service and partners have developed BMPs to help minimize adverse effects from these activities to the Speckled Pocketbook and its habitat.

A programmatic SHA was signed in 2007 to encourage private landowner conservation efforts. The SHA has enabled resource agencies and conservation groups to prioritize recovery efforts, achieve substantive conservation measures (e.g., Archey Fork restoration project) while fostering partnerships with private landowners, municipalities, and industry to promote recovery for this species.

The status of the Speckled Pocketbook continues to improve. However, Speckled Pocketbook should remain listed as an endangered species due to threats listed under Factors A, D and E above. The Service and its partners continue to make progress in obtaining additional monitoring data. When additional monitoring data is available, it will allow us to better ascertain population trends and status. We recommend reexamining the recovery criteria to measure future recovery progress towards reclassification and delisting.

III. RESULTS

A. Recommended Classification:

The status of Speckled Pocketbook should remain unchanged.

B. Recovery Priority Number __8___

The degree of threat to the Speckled Pocketbook is moderate because there is a continual threat to its habitat (*e.g.* primarily from poor land use practices, illegal activities such as gravel mining, and habitat fragmentation). The recovery potential is high because the biology is well understood as well as ecological factors affecting the

biology. Threats are well understood and these threats should be alleviated through the SHA and other conservation initiatives.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Increase landowner enrollment in the programmatic SHA. Successful implementation of this agreement is essential to alleviating threats to water quality and habitat, thereby allowing for natural expansion of populations into uninhabited stream reaches and providing protection for existing extant populations.

2. The recovery plan should be revised to refine reclassification criteria, define delisting criteria, and better address the five factors.

3. Continue to collect data on size structure of extant Speckled Pocketbook populations.

4. Determine importance of gene flow between different stream populations.

5. Determine status of suitable host fish in the upper Little Red River watershed (*e.g.*, how does their distribution match the distribution of Speckled Pocketbook?).

6. Determine habitat requirements of suitable host fish, condition/status of habitat (e.g., pristine, degraded, etc), and restoration/protection needs.

7. Continue to foster a working partnership with county governments, municipalities, industry, and private landowners to help minimize threats and promote recovery of Speckled Pocketbook.

8. Monitor population status in the four forks of the Little Red River.

9. Collect baseline information on distribution and abundance of Speckled Pocketbook in Big Creek.

V. REFERENCES

Allen, D. C., B. E. Sietman, D. E. Kelner, M. C. Hove, J. E. Kurth, J. M. Davis, J. L. Weiss, and D. J. Hornbach. 2007. Early life-history and conservation status of *Venustaconcha ellipsiformis* (Bivalvia, Unionidae) in Minnesota. American Midland Naturalist **157**:74-91.

Bartsch, M. R., D. L. Waller, G. W. Cope, and S. Gutreuter. 2000. Emersion and thermal tolerances of three species of unionid mussels: survival and behavioral effects. Journal of Shellfish Research 19:233-240.

Clarke, A.E. 1987. Status survey of *Lampsilis streckeri* Frierson (1927) and *Arcidens wheeleri* (Ortmann and Walker 1912). A report to the U. S. Fish and Wildlife Service. 24pp. plus field notes.

Davidson, C. and M. Wine. 2004. Threats assessment for the Speckled Pocketbook (*Lampsilis streckeri*) and yellowcheek darter (*Etheostoma moorei*) in the upper Little Red River watershed, Arkansas. Unpubl. Report. U. S. Fish and Wildlife Service, Arkansas Field Office, Conway, Arkansas. 28pp. + appendix.

Davidson, C. 2005. Threats assessment for the Speckled Pocketbook (*Lampsilis streckeri*) and yellowcheek darter (*Etheostoma moorei*) in the upper Little Red River watershed, Arkansas. Addendum 1: Archey Fork Little Red River. Unpubl. Report. U. S. Fish and Wildlife Service, Arkansas Field Office, Conway, Arkansas. 7pp.

Fuller, S.L.H. 1974. Clams and mussels (Mollusca: Bivalvia). Pp. 215-273 *in*: C.W. Hart, Jr., and S.L.H. Fuller, eds. Pollution ecology of freshwater invertebrates. Academic Press, New York.

Galbraith, H.S., D.E. Spooner, and C.C. Vaughn. 2010. Synergistic effects of regional climate patterns and local water management on freshwater mussel communities. Biological Conservation 143:1175-1183.

Gray, E. V. S., W. A. Lellis, J. C. Cole, and C. S. Johnson. 2002. Host identificaiton for *Strophitus undulatus* (Bivalvia:Unionidae), the Creeper, in the Upper Susquehanna River Basin, Pennsylvania. Am. Midl. Nat. 147:153-161.

Harris, J.L. 1991. Survey for *Lampsilis streckeri* in the Midle Fork Little Red River at the proposed NOARK pipeline crossing, Van Buren County, Arkansas. Prepared for ENSR Consulting and Engineering, Houston, TX. 10pp.

Harris, J.L. 1992. Status of *Lampsilis streckeri* in segments of the Middle, South, and Archey forks of the Little Red River, Stone and Van Buren counties, Arkansas. Prepared for the U. S. Fish and Wildlife Service, Endangered Species Office, Jackson, MS. 23pp. + field notes.

Harris, J.L. 1993. Habitat characterization and species associates of the speckled pocketbook (*Lampsilis streckeri*) in the Middle Fork Little Red River, Arkansas. Prepared for the U. S. Fish and Wildlife Service, Endangered Species Office, Jackson, MS. 28pp. plus appendices.

Harris, J.L., P.J. Rust, A.C. Christian, W.R. Posey II, C.L. Davidson, and G.L. Harp. 1998. Revised status of rare and endangered Unionacea (Mollusca: Margaritiferidae, Unionidae) in Arkansas. Journal of the Arkansas Academy of Science 51 (1997):66-89.

Harris, J.L., W. R. Hoeh, A.D. Christian, J. Walker, J.L. Farris, R.L. Johnson, and M.E. Gordon. 2004. Species limits and phylogeography of Lampsilinae (Bivalvia: Unionida) in Arkansas with emphasis on species of *Lampsilis*. Prepared for Arkansas Game and Fish Commission and U. S. Fish and Wildlife Service. 61pp. + appendix.

Harris, J.L., W.R. Posey II, C.L. Davidson, J.L. Farris, S.R. Oetker, J.N. Stoeckel, B.G. Crump, M.S. Barnett, H.C. Martin, M.W. Matthews, J.H. Seagraves, N.J. Wentz, R. Winterringer, C. Osborne, and A.D. Christian. 2010a. Unionida (Mollusca: Margaritiferidae, Unionidae) in Arkansas, Third Status Review. Journal of the Arkansas Academy of Science 63 (2009):50-86.

Harris, J.L., A.D. Christian, and W.R. Hoeh. 2010b. Hidden diversity in Arkansas freshwater mussels: description of new species and new genera with determination of species ranges for members of the genus Lampsilis (Bivalvia: Unionida). Unpubl. Report submitted to Arkansas Game and Fish Commission, Little Rock, AR. 31pp. + appendices.

Schwalb, A. N., and M. T. Pusch. 2007. Horizontal and vertical movements of unionid mussels in a lowland river. Journal of the North American Benthological Society 26:261-272.

Steingraeber, M. T., M. R. Bartsch, J. E. Kalas, and T. J. Newton. 2007. Thermal Criteria for Early Life Stage Development of the Winged Mapleleaf Mussel (*Quadrula fragosa*). American Midland Naturalist 157:297–311.

U. S. Fish and Wildlife Service. 1989. Endangered and threatened wildlife and plants: endangered status for the Speckled Pocketbook (*Lampsilis streckeri*). Federal Register 54(38):8339-8341.

U. S. Fish and Wildlife Service. 1992. Speckled Pocketbook Mussel (*Lampsilis streckeri*) Recovery Plan. U. S. Fish and Wildlife Service. Jackson, MS. 14pp.

U. S. Fish and Wildlife Service. 2005. Conservation strategy for the Speckled Pocketbook (*Lampsilis streckeri*) and Yellowcheek Darter (*Etheostoma moorei*). U. S. Fish and Wildlife Service. Conway, AR. 22pp.

U.S. Fish and Wildlife Service. 2007. Speckled Pocketbook (Frierson 1927) five year review: summary and evaluation. U.S. Fish and Wildlife Service. Conway, AR. 15pp.

U.S. Fish and Wildlife Service. 2013. Status report: programmatic safe harbor agreement and candidate conservation agreement with assurances in the upper Little Red River watershed, Arkansas. U.S. Fish and Wildlife Service. Conway, AR. 11pp.

Watters, G.T. and S.H. O'Dee. 1999. Glochidia of the freshwater mussel *Lampsilis* overwintering on fish hosts. The Journal of Molluscan Studies 65(4):453-459.

Watters, G.T. and S.H. O'Dee. 2000. Glochidial release as a function of water temperature: Beyond bradyticty and tachyticty. Pp. 135-140 *in:* R.A. Tankersley *et al.,* eds. Proceedings of the Conservation, Captive Care, and Propagation of Freshwater Mussels Symposium, 1998. Ohio Biological Survey Special Publications, Columbus, Ohio.

Watters, G.T., S.H. O'Dee, and S. Chordas. 2001. Patterns of vertical migration in freshwater mussels (Bivalvia: Unionoida). Journal of Freshwater Ecology 16:541-549.

Winterringer, R. 2003. Population dynamics and reproductive patterns of the federally endangered freshwater mussel, *Lampsilis streckeri* (Frierson 1927). M.S. thesis. Arkansas State University, State University, Arkansas. 74pp.

VI. PEER REVIEW

A draft copy of this 5-year review was sent to the following knowledgeable individuals for their review and comment:

Bill Posey, Arkansas Game and Fish Commission

Josh Seagraves, Arkansas Highway and Transportation Department

Dr. John Harris, Arkansas State University

Results of Peer Review:

Josh Seagraves provided minor editorial changes.

Dr. John Harris provided minor editorial changes. Dr. Harris also questioned whether the recovery potential is high for Speckled Pocketbook.

Our Response: The Service recovery priority guidelines (48 FR 43104) establishes a process for determining a species recovery priority based on taxonomy (*i.e.,* monotypic genus, species, subspecies), degree of threat (*e.g.,* high, moderate, low) and recovery potential (*e.g.,* high or low). Our guidance defines a moderate threat as the species will not face extinction if recovery is temporarily held off, although there is continual population decline or threat to its habitat. A high threat priority for Speckled Pocketbook is not appropriate because extinction is not almost certain in the immediate future. A low threat priority also is not appropriate because Speckled Pocketbook populations are not experiencing short-term, self-correcting, or unknown threats to its habitat.

High or low recovery potential is based on our understanding of biological and ecological limiting factors (*i.e*., well understood or poorly understood), threats to species existence (*i.e.,* well understood and easily alleviated or poorly understood, pervasive, and difficult to alleviate), and management needs (*i.e*., intensive management not needed or techniques with high probability of success or intensive management with uncertain probability of success). We

acknowledge that construction of Greers Ferry Reservoir isolated populations in three of four forks of the Little Red River and permanently extirpated the species from the main stem Little Red River. However, biological and ecological requirements for the species are well understood, threats are being addressed through the SHA and similar conservation efforts (*e.g.*, Archey Fork restoration project), and propagation techniques are established and have been proven successful should the need arise to augment or reintroduce populations. Based on our criteria for establishing recovery potential, it is the Service's opinion that recovery potential is overwhelmingly high for Speckled Pocketbook. Therefore, a species with moderate threat and high recovery potential should be assigned a recovery priority number of eight (8).

Bill Posey provided one comment related to Harris *et al*. (2004). Harris *et al.* (2004) revealed that *Lampsilis reeviana* co-occurs with Speckled Pocketbook in the Little Red River basin. He concludes that this information confounds the known number of Speckled Pocketbook in the Little Red River basin due to morphological similarity of appearance and may result in an over estimate for Speckled Pocketbook.

Our Response: Mr. Posey mistakenly referenced Harris *et al*. (2004). The reference about co-occurrence of Speckled Pocketbook and *Lampsilis reeviana* occurs in Harris *et al.* (2010b). We addressed this comment by adding the following paragraph to page 5 under Task 2.3.

Harris *et al.* (2010b) further explored genetic relationships between Speckled Pocketbook and *L. reeveiana*. They suggested that *L. reeveiana* and Speckled Pocketbook may co-occur in the Little Red River basin. However, there is no reason to assume that *L. reeveiana* like individuals/populations could maintain genetic isolation among a population that is overwhelmingly Speckled Pocketbook. Speckled Pocketbook is a relatively recent divergence from *L. reeveiana* and the divergence is shallow. Therefore, some Speckled Pocketbook specimens may come out more closely aligned with *L. reeveiana* in some analyses, but they are still Speckled Pocketbook (Harris 2015, pers. comm.).

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Speckled Pocketbook (*Lampsilis streckeri*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change is needed

Review Conducted By Chris Davidson, USFWS Arkansas Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 3/17/2015

5-YEAR REVIEW OF SPECKLED POCKETBOOK (*Lampsilis streckeri*)

Addendum 1. Summary of new information obtained since the 2015 5-Year Review

The *Federal Register* notice announcing the initiation of this 5-year review published on June 23, 2021 (86 FR 32965). The U.S. Fish and Wildlife Service (Service) does have additional information about the species obtained by the Service and Arkansas Game and Fish Commission (AGFC) biologists. We present this updated information below.

We received one public comment letter during the public comment period and incorporated those comments, where appropriate. We maintain a record of all public comments and responses in the administrative record for this review. We have not received significant new information since the last status review and the level of public interest is low and non-controversial. Therefore, we did not conduct peer review.

I. GENERAL INFORMATION

B. Reviewers

Lead Region: Interior Regions 2 & 4, Carrie Straight, (404) 679-7226

Lead Field Office: Arkansas Ecological Services Field Office, Chris Davidson (501) 513-4481

Cooperating Field Office: Not applicable (species endemic to Arkansas)

C. Background

1. **Federal Register notice initiating this review:** (86 FR 32965), DATE, 2021.

   Species Status: Declining. Based on long-term monitoring data obtained by the Service and AGFC staff, the Speckled Pocketbook population in Archey and Devil's Forks appear stable, albeit small. In the South and Middle Forks, number of individuals declined by 64 and 31 percent, respectively during the past decade. The Big Creek population is extremely small and 2019 surveys failed to detect the species. The Service and AGFC stocked 165 individuals at three Big Creek sites in 2021. Overall, Speckled Pocketbook appears to be declining. However, propagation efforts are proving successful and ongoing augmentation efforts may help reverse this trend until other conservation initiatives improve environmental conditions.

4. **Review history:** The Service finalized a 5-year review for Speckled Pocketbook in 2015. The review recommended the species remain classified as endangered due to its narrow range and known threats (Service 2015).

7. **Recovery plan:** The Service finalized an amendment to the Speckled Pocketbook (*Lampsilis streckeri*) Recovery Plan on September 26, 2019 (Service 2019). See Section II.B below for more detail.

II. REVIEW ANALYSIS

B. Recovery Plan and Criteria

2. Adequacy of recovery criteria

a. Do the recovery criteria reflect the best available and most up to date information on the biology of the species and its habitat? Yes. Speckled Pocketbook will be considered for delisting when:

1. Three existing populations in the South Fork (1), Middle Fork (1), and Archey Fork (1) exhibit a stable or increasing trend, natural recruitment, and multiple age classes (Factors A, D, & E).

2. Individuals in populations (as defined in Criterion 1) are spatially distributed sufficient to protect against stochastic and catastrophic events.

3. Threats have been addressed and/or managed to the extent that the species will remain viable into the foreseeable future (Factors A, D, & E).

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and there is no new information to consider regarding existing or new threats)? Yes.

3. List the recovery tasks as they appear in the recovery plan, and discuss how each task has or has not been achieved. The 2019 recovery plan amendment revised the following recovery tasks. Where new information is available for a task since the 2015 5-year review and 2019 recovery plan amendment, we provide additional information below.

Revised Part II B.1 (page 5) as follows: Protect known populations and their habitats from further adverse effects. The continued survival of this species requires that every effort is expended to protect these populations. **Update:** See Conservation Measures section below.

Revise Part II B.1.1 (page 5) as follows: Conduct population surveys. Monitor populations at 7-year intervals to establish trends. Big Creek should be comprehensively surveyed to establish current distribution and abundance of Speckled Pocketbook and then monitored at the same interval as other populations. **Update:** The Service and AGFC surveyed Big Creek in 2019. Monitoring of the four forks of the Little Red River occurred in 2016 – 2017, 2019 – 2020, and in conjunction with ongoing propagation and augmentation efforts.

Revised Part II B.2.0 (page 6) as follows: Conduct research on the species. While protecting Speckled Pocketbook and its habitat, it is important to address data gaps regarding the species biological requirements to ensure survival and

recovery. This task should address important life history and water and sediment quality and quantity requirements. **No updates.**

Added the following recovery activity to Part II B.2.0 (page 6): 2.4 Determine genetic variation within and among populations. Knowing the genetic structure and diversity of Speckled Pocketbook will inform future conservation recovery tasks. Populations are isolated from one another by Greers Ferry Reservoir. This recovery task will analyze the genetic structure and diversity of extant populations. It will provide information on population heterozygosity, observed number of alleles, and effective population size. **Update:** The Service and AGFC funded this task and it is currently ongoing.

Added the following recovery activity to Part II B.2.0 (page 6): 2.5 Determine sediment deposition rates vs. survivorship of Speckled Pocketbook. Excessive sedimentation and its associated effects are not good for mussels or free-flowing streams. Many mussel declines have been attributed to sedimentation from a variety of land use activities. Understanding why nearly all mussel species have exhibited population declines when some species are silt tolerant (and in some cases silt dependent) is important to understanding the stressors limiting population growth. This recovery task will provide information on particle size, rate of deposition, timing of deposition events, and how bed load dynamics influence Speckled Pocketbook survival. **No updates.**

Revised Part II B.3.2 (page 7) as follows: Develop a plan for reestablishing mussel populations. "… by transplanting from extant populations, …". Remove and replace the last sentence in Part II B.3.2 as follows: Evaluate existing habitat and assess suitability of sites considered for reintroduction and augmentation. Ensure genetic stock representative of genetic diversity. **Update:** The Service and AGFC finalized a propagation, augmentation, and reintroduction plan in 2020.

Revised Part II B.3.3 (page 7) as follows: Implement plan to restore historical habitat. Based upon information gained through The Nature Conservancy's (TNC) bank erosion hazard index and unpaved roads inventory, as well as current distribution and abundance of Speckled Pocketbook, the lower South Fork (defined as areas downstream of Lo Gap Road) and upper Middle Fork (defined as areas upstream of Elba) should be the highest priority for habitat restoration. **Update:** Numerous unpaved road projects implemented in Stone and Van Buren counties under the Arkansas Unpaved Roads Program administered by the Arkansas Department of Agriculture – Natural Resources are improving water and habitat quality by reducing sediment runoff from county roads. The Service is also working with TNC, AGFC, and other partners to remove fish barriers in the Middle Fork.

Revised Part II B.4.1 (page 7) as follows: Determine effective population size. See Action 2.0. This action will determine the effective population size required

for viable populations through population genetics. **Update:** Task funded and currently ongoing.

C. Updated Information and Current Species Status

1. Biology and habitat

a. Spatial distribution, abundance, and population trends

The species currently occurs in four watersheds (described below). Since the last 5-year review, the Service and AGFC have not been able to locate any individuals in Big Creek. The populations in the Middle and South forks are declining based on a lower number of individuals encountered during surveys. In the Middle Fork, even though abundance declined, the species' distribution slightly increased. In 2019, the AGFC and Service released approximately 500 juveniles in the Archey and Middle forks and propagation efforts are expanding in the remaining forks.

Archey Fork Little Red River –Historical surveys for Speckled Pocketbook are limited to three sites in the 1980s. No Speckled Pocketbook were collected during these surveys (Harris 1985, Clarke 1987). Speckled Pocketbook (N = 33) was rediscovered at seven sites in the Archey Fork in 2005. In subsequent surveys in 2009 – 2010, 2016 and 2019, it has been found at 6 additional sites (Davidson pers. comm. 2021). The AGFC and Service established long-term monitoring stations at five sites in 2009, an additional three sites in 2016, and one site in 2019. A total of 34 individuals were collected from the long-term monitoring sites in 2009 – 2010, 39 individuals in 2016, and 13 individuals from a new site added in 2019 (Table 1). Suitable habitat patches are relatively small and dynamic (prone to disappear and reappear at different locations) as stream geomorphology changes. Cage culture at Greers Ferry Reservoir produced 1,882 Speckled Pocketbook juveniles from Archey Fork brood in 2020. Of these individuals, the Service and AGFC stocked 395 juveniles at 12 sites in Archey Fork in the fall of 2020 and 248 individuals at one site in 2021 (Davidson pers. comm. 2021). Overall, the Speckled Pocketbook population appears stable, albeit small, in Archey Fork.

Devils Fork Little Red River – The Devils Fork has three different names depending on the reach, with the uppermost reach (upstream of Tomahawk Creek) referred to as Turkey Creek; the middle reach (between the confluences of Tomahawk and Raccoon creeks) referred to as Beech Fork; and lowermost reach (downstream of Raccoon Creek) referred to as the Devils Fork. Speckled Pocketbook (N = 5) was rediscovered at two sites in Turkey Creek and Beech Fork in 2004. In two subsequent surveys (2010 and 2016), no live Speckled Pocketbook were found at these two sites. However, surveyors discovered one new site in Turkey Creek and two new sites in Beech Fork in 2010. Twelve individuals were collected from these three sites. The same number of individuals were collected at the two Beech Fork sites in 2016, but none from Turkey Creek (Davidson pers. comm. 2021). In 2019, surveyors collected seven Speckled Pocketbook from Site BFM04 (Table 1), but survey conditions were less than favorable (high water, low visibility). Suitable habitat patches are relatively

small and dynamic as stream morphology changes. Beech Fork contains numerous large boulders that may provide suitable habitat for Speckled Pocketbook but are not accessible due to their size and weight. Overall, the Speckled Pocketbook population is small and extant at two Beech Fork locations.

Middle Fork Little Red River – Forty-three (43) sites were surveyed in the Middle Fork from 1976 – early 1990s. Speckled Pocketbook was present at 20 sites (43%) (Clarke 1987, Harris 1991, Harris 1992a, Harris 1992b, Harris 1993, Posey pers. comm. 2014). Winterringer (2003) surveyed 13 sites and Speckled Pocketbook was present at five sites (38%). Three of these sites with Speckled Pocketbook presence were newly discovered sites. The AGFC and Service surveyed six sites from 2004 – 2006 and found 39 live Speckled Pocketbook (Davidson pers. comm. 2021).

Systematic surveys of the entire river began in 2009 when 19 long-term monitoring stations were established by AGFC and the Service (Davidson pers. comm. 2021). One hundred twenty (120) live Speckled Pocketbook were collected from the long-term monitoring stations in 2009 – 2010 (Table 1) plus three additional live animals from other sites. From 2016 – 2018, all of these sites plus one new site were resurveyed. Eighty-three (83) live individuals were collected during the 2016 – 2018 survey (Table 1) (Davidson pers. comm. 2021). Speckled Pocketbook number of live individuals increased at five sites (25%) between the 2009 – 2010 and 2016 – 2018 surveys. Of the 75 percent of sites with fewer Speckled Pocketbook, 10 sites had zero live individuals (Davidson pers. comm. 2021). In 2019, the AGFC and Service surveyed reaches previously not surveyed upstream of Little Red Creek and located one new site with seven Speckled Pocketbook; extending the known range upstream 3.2 river miles. Six Speckled Pocketbook were collected from another new site the same year a short distance upstream of Shirley, Arkansas. Fifteen additional individuals were collected from two long-term monitoring sites and another historical location to obtain genetic samples (Davidson pers. comm. 2021). In 2019, the Service and AGFC stocked 112 juveniles produced from Middle Fork at four locations in the Middle Fork. Overall Speckled Pocketbook appears to be declining in the Middle Fork.

South Fork Little Red River –Prior to 2004, Speckled Pocketbook was only known from three sites in the lower South Fork (Harris 1985, Clarke 1987, Harris 1992b). From 2004 – 2006, 22 live and 2 fresh dead Speckled Pocketbook were collected from 6 sites (Davidson pers. comm. 2018). The AGFC and Service established five long-term monitoring stations in 2009. Fifty-nine (59) live individuals were collected from these sites (Table 2). Twenty-one (21) live individuals were collected from these same sites in 2016. Number of live individuals declined at all sites (Table 1) (Davidson pers. comm. 2018). In 2019, two of these sites were resurveyed to collect genetic samples and 8 individuals were found. In addition, 17 individuals were collected from two new sites (Table 1). Speckled Pocketbook is restricted to the upper reach of the South Fork where habitat patch size is small, and the population appears to be declining.

Table 1. Speckled Pocketbook long-term monitoring stations in the upper Little Red River basin, Arkansas (Davidson pers. comm. 2021). NS = not sampled. TMTC = too many to count. * genetic samples, not representative of a complete site survey.

Site	# Live Speckled Pocketbook (SP)						Male:Female SP			# Species Present				# Total Live Mussels			
	1991	2001	2004	2009/2010	2016-2018	2019	2009/2010	2016-2018	2019	2004	2009/2010	2016-2018	2019	2004	2009/2010	2016-2018	2019
Devils Fork Complex (Turkey Creek, Beech Fork, Devils Fork)																	
TC01	NS	NS	NS	2	0	NS	1:1	-	-	-	5	1	-	-	7	2	-
TC02	NS	NS	NS	0	0	NS	-	-	-	-	5	2	-	-	29	3	-
BF01	NS	NS	3	0	-	NS	-	-	-	5	0	-	-	88	0	-	-
BF02	NS	NS	2	0	0	NS	-	-	-	11	4	6	-	37	8	2	-
BF03	NS	NS	NS	2	2	NS	1:1	1:1	-		6	5	-	-	12	4	-
BF04	NS	NS	NS	8	8	7	5:3	1:3	3:4		8	6	4	-	52	30	NC
Archey Fork																	
AF01	NS	NS	NS	NS	22	13*	-	13:9	9:6	-	-	5	-	-	-	65	-
AF02	NS	NS	4	3	3	NS	3:0	-	-	6	6	3	-	16	8	8	-
AF03	NS	NS	NS	2	0	NS	2:0	-	-	-	4	1	-	-	28	1	-
AF04	NS	NS	NS	15	0	NS	7:5	-	-	-	5	2	-	-	24	2	-
AF05	NS	NS	2	2	3	NS	1:1	1:2	-	7	8	10	-	45	TMTC	30	-
AF06	NS	NS	NS	12	NS	NS	5:7	-	-	-	10	-	-	-	65		-
AF07	NS	NS	NS	NS	6	NS	-	3:2	-	-	-	3	-	-	-	7	-
AF08	NS	NS	NS	NS	3	NS	-	2:1	-	-	-	2	-	-	-	5	-
AF09	NS	NS	NS	NS	NS	12	-	-	5:7	-	-	-	5	-	-	-	96
South Fork																	
SF02	NS	NS	NS	17	1	3	7:4	0:1	1:2	-	4	3	4	-	91	22	12
SF03	NS	NS	NS	14	9	5	5:9	5:4	3:2	-	4	4	3	-	117	42	12
SF04	NS	NS	NS	12	1	NS	6:6	0:1	-	-	3	3	-	-	16	6	-
SF05	NS	NS	NS	5	3	NS	4:1	1:2	-	-	4	5	-	-	7	9	-
SF06	NS	NS	2	11	7	NS	5:6	4:3	-	4	3	6	-	11	18	24	-
SF05B	NS	NS	NS	NS	NS	10	-	-	7:3	-	-	-	4	-	-	-	16
SF05C	NS	NS	NS	NS	NS	7	-	-	5:2	-	-	-	1	-	-	-	7
Middle Fork																	
MF01	1R	NS	NS	6	0	NS	3:3	-	-	-	17	15	-	-	489+	347	-
MF02	NS	NS	NS	1	0	NS	-	-	-	-	16	9	-	-	228	105	-
MF03	NS	17	NS	0	1	NS	-	1:0	-	-	17	15	-	-	195	123	-
MF04	NS	NS	NS	0	1	NS	-	1:0	-	-	11	9	-	-	26	26	-
MF05	NS	NS	NS	17	24	8	10:7	16:8	3:5	-	10	11	5	-	85	116	40
MF06	0	NS	NS	1	0	NS	-	-	-	-	4	4	-	-	7	7	-
MF07	NS	NS	NS	0	-	NS	-	-	-	-	0	-	-	-	0	-	-
MF08	NS	NS	0	2	0	NS	2:0	-	-	9	10	6	-	163	205	195	-
MF09	NS	NS	7	2	0	NS	1:1	-	-	7	7	1	-	43	19	3	-
MF10	NS	NS	NS	3	0	NS	2:1	-	-	-	4	1	-	-	4	1	-
MF11	NS	10	22	20	14	10	18:2	11:3	-	-	12	10	-	-	100	61	-
MF12	NS	NS	NS	16	8	6	8:7	-	5:1	-	8	4	8	-	40	18	44
MF13	NS	NS	NS	3	0	1	1:2	-	1:0	-	10	0	2	-	18	0	2
MF14	NS	NS	NS	3	0	NS	2:1	-	-	-	3	0	-	-	5	0	-
MF15	NS	NS	NS	10	11	NS	4:4	4:3	-	-	9	12	-	-	35	50	-
MF16	NS	NS	NS	5	13	NS	3:2	2:3	-	-	7	9	-	-	19	49	-
MF17	NS	NS	NS	2	1	NS	2:0	-	-	-	6	4	-	-	14	10	-
MF18	NS	NS	NS	7	0	NS	4:2	-	-	-	8	0	-	-	20	0	-
MF19	NS	NS	NS	22	0	NS	9:7	-	-	-	12	6	-	-	118	31	-
MF20	NS	NS	NS	NS	10	NS	-	6:4	-	-	-	2	-	-	-	14	-
MF100	NS	NS	NS	NS	NS	6	-	-	3:2:1	-	-	-	5	-	-	-	19
MF101	NS	NS	NS	NS	NS	7	-	-	6:1	-	-	-	4	-	-	-	18

Big Creek – There are two Big Creeks in the Little Red River basin, both converging with the Little Red River near Pangburn, Arkansas. Speckled Pocketbook occurs in the Big Creek that converges at the Little Red River's north bank. No comprehensive surveys of Big Creek existed until 2019 due to limited access points. One live and 11 dead Speckled Pocketbook were collected from three sites in 2005 (Davidson pers. comm. 2021). Based on a 2019 survey of approximately 17 river miles considered suitable habitat for mussels in Big Creek, surveyors failed to locate Speckled Pocketbook. An unknown catastrophic event that affected the entire aquatic community apparently affected the creek, as only 4 mussel species represented by 17 individuals and very few fish were observed during the survey. As testament to the paucity of fish observed, biologists also did not observe *Agksitrodon piscivorus* (Cottonmouth; a snake that relies primarily on small fish and frogs for its diet) which differed from the substantial number observed during prior trips to Big Creek (Davidson pers. comm. 2021). The Service and AGFC stocked 165 Speckled Pocketbook at three Big Creek sites in 2021.

b. Demographics

We analyzed all available sex data on Speckled Pocketbook from 1991 - 2018. Sex ratio was 1:1.4 (187 females, 257 males). The sex ratios for South Fork and Devils Fork were 1:1, while Middle Fork and Archey Fork skewed towards males. Mean length for Speckled Pocketbook in the Middle, South, Archey, and Devils forks is 63.9 (SD = 13.6), 65.1 (SD = 8.5), 72.5 (SD = 9.3), and 65.7 mm (SD = 10.6), respectively (Figures 1 – 3) (Harris 1992a, 1992b, Winterringer 2003, Davidson pers. comm. 2021). The apparent absence of smaller individuals (<40 mm) may indicate a lack of or low recruitment, particularly in the Middle Fork where there was a shift towards larger animals since 2016, or may be due to greater difficulty locating smaller individuals. No size data exists for Speckled Pocketbook from Big Creek.

2. Five Factor Analysis (threats)

a. **Present or threatened destruction, modification or curtailment of its habitat or range:**

Impoundments - The construction of Greers Ferry Reservoir resulted in the permanent loss of habitat and isolation of populations (Middle and Devils forks, Big Creek) due to inundation and cold tailwater releases downstream of the dam. Information on gene flow between populations and effective population size is lacking at this time. These isolated populations become more prone to extirpation from stochastic events, such as severe drought, and catastrophic events, such as chemical spills or unauthorized discharges (Layzer *et al.* 1993; Cope *et al.* 1997; Neves *et al.* 1997; Watters 2000; Miller and Payne 2001; Pringle *et al.* 2000; Watters and Flaute 2010).

Figure 1. Length frequency for Speckled Pocketbook collected from the Devils Fork Little Red River, 2009 – 2018 (Davidson pers. comm. 2021)

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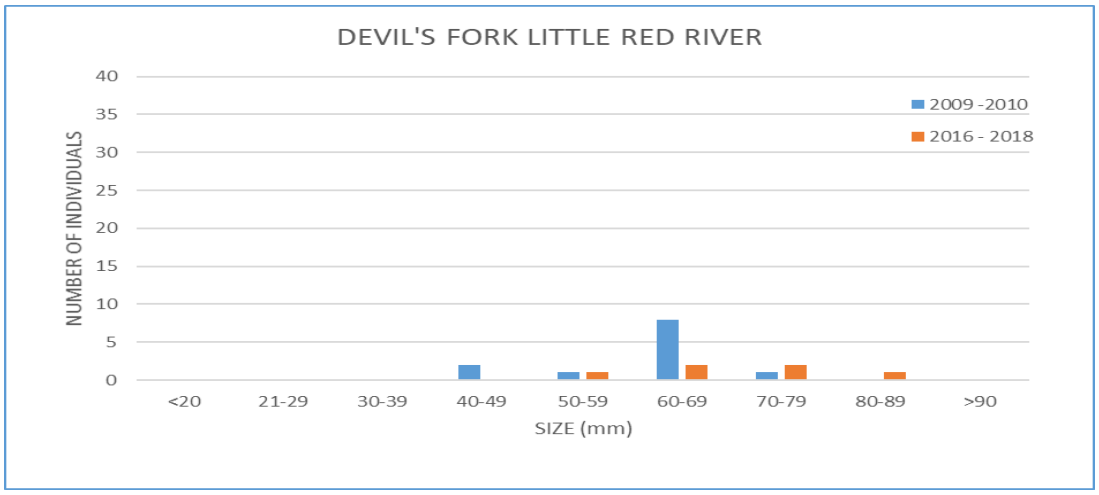


Figure 2. Length frequency for Speckled Pocketbook collected from the Middle Fork Little Red River, 1991 – 2018 (Harris 1992a, 1992b, Winterringer 2003, Harris pers. comm. 2004, Davidson pers. comm. 2021).

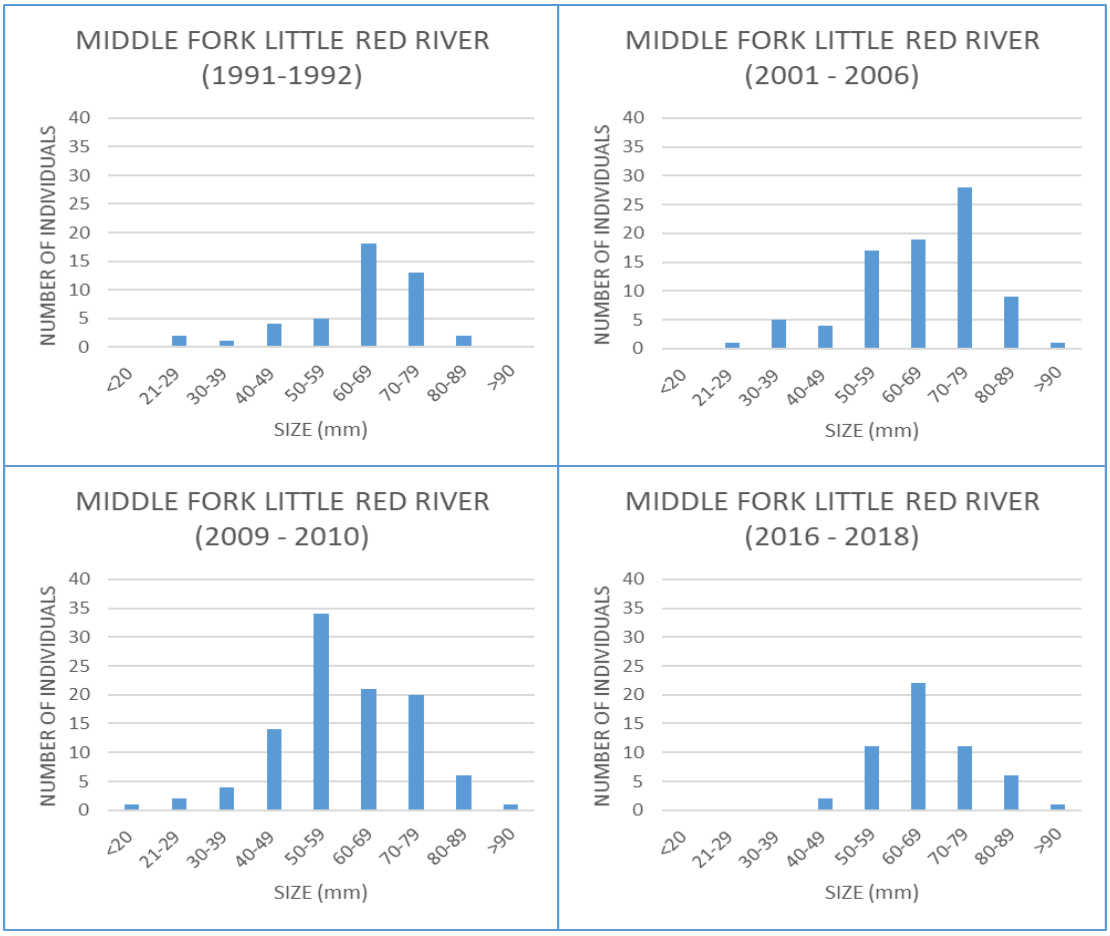
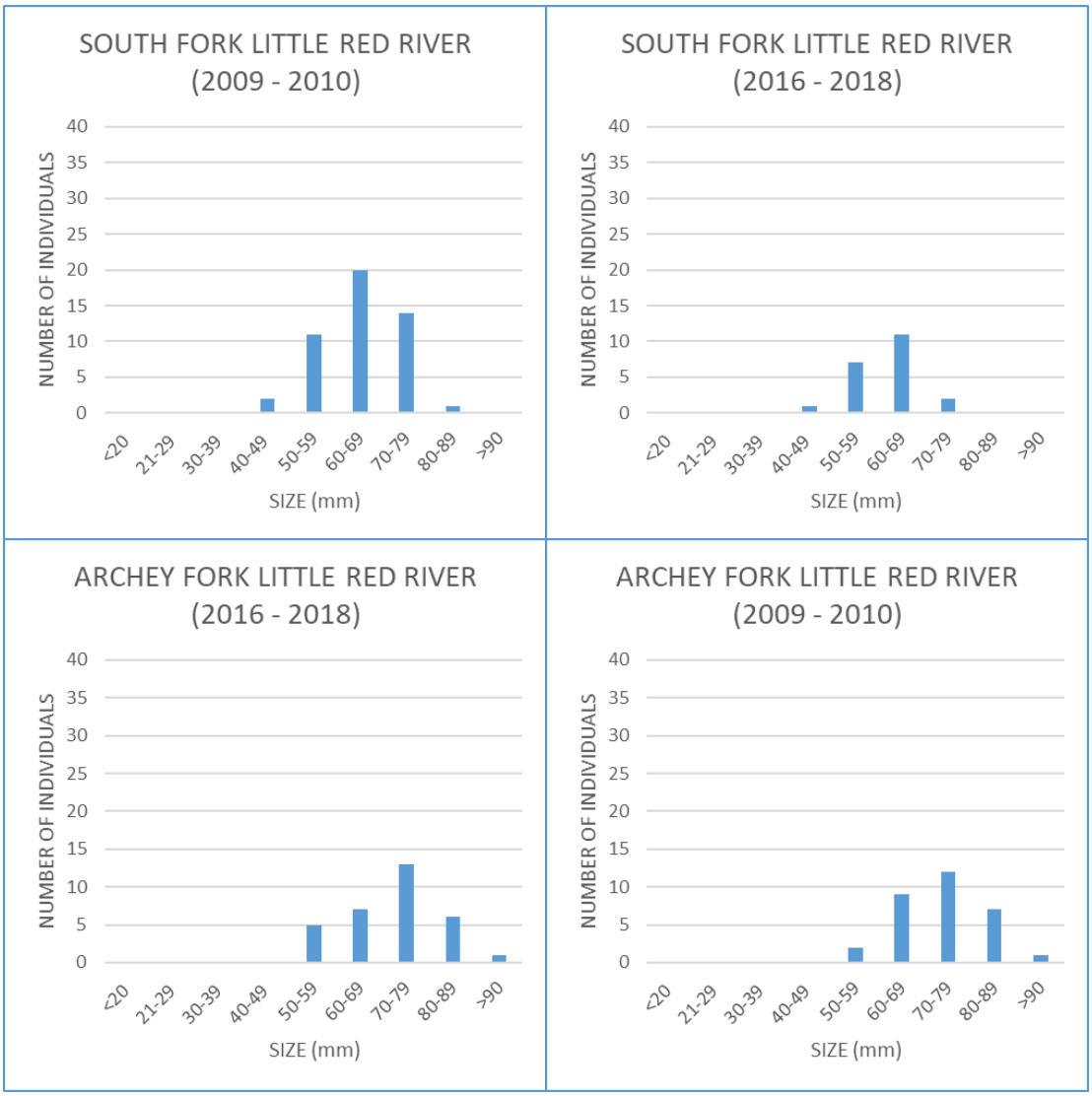


Figure 3. Length frequency for Speckled Pocketbook collected from the Archey and South forks of the Little Red River, 1991 – 2018 (Davidson pers. comm. 2021).



Sedimentation – Excessive sediments adversely affect riverine mussel populations requiring clean, stable streams (Ellis 1936; Brim Box and Mossa 1999). Sediment affects most localities occupied by Speckled Pocketbook to varying degrees. Studies indicate the primary effects of excess sediment levels on mussels are generally sublethal, with detrimental effects not immediately apparent (Brim Box and Mossa 1999). The physical effects of sediment on mussel habitat appear to be multifold, and include changes in suspended and bed material load, bed sediment composition associated with increased sediment production and runoff in the watershed, channel changes in form, position, and degree of stability, changes in depth or the width and depth ratio that affects light penetration and flow regime, actively aggrading (filling) or degrading (scouring) channels, and changes in channel position.
Increased sedimentation may explain in part why Speckled Pocketbook is experiencing declines in some streams. Sediment sources in the Speckled

Pocketbook's range derive from a variety of land use practices (e.g. gravel and rock mining, agricultural, irresponsible forestry practices, dirt and gravel road maintenance and construction, etc.). Two primary sources of sediment in rural forested watersheds, including the upper Little Red River watershed, are eroding stream banks and unpaved roads. Even during small rainfall events, storm water runoff from unpaved roads and ditches can contribute suspended sediment to streams and creeks resulting in elevated turbidity and total suspended solids concentrations. Increases in construction activities related to the development of the Fayetteville shale gas play from 2006 – 2012 exacerbated sediment issues in the southern portions of the South, Archey, and Middle forks and Big Creek (Davidson pers. comm. 2021). Natural gas infrastructure development has subsided substantially since circa 2012; however, its legacy effects may linger for years or decades. It appears unlikely, at this time, that substantial development of mineral resources (i.e., natural gas) will occur in the upper South Fork, mid to upper Middle Fork, Archey Fork, and upper Devils Fork watersheds in the near future due to insufficient gas reserves and market demand.

Water Diversion – The non-riparian water use (NRWU) program administered by the Arkansas Department of Agriculture - Natural Resources is designed to monitor surface water use outside of the riparian zone through the evaluation of surface water diversions, and subsequent determination actions (to include permits where appropriate) associated with each use. Surface water diversions require certification from the state verifying the use of surface water will comply with the Arkansas State Water Plan and applicable state water law. There are 13 NRWU permits currently issued in the watersheds of the four forks of the Little Red River and Big Creek (Jackson, pers. comm. 2018). Increases in construction activities related to the development of the Fayetteville shale gas play from 2006 – 2012 exacerbated water diversion issues in the lower portions of the South, Archey, and Middle forks and Big Creek (Davidson pers. comm. 2018). Now that natural gas infrastructure development has subsided substantially, water diversion is not a threat.

Mining – Gravel and rock mining are activities that may negatively affect water quality in Speckled Pocketbook habitat. Instream and alluvial gravel mining has been implicated in the destruction of mussel populations (Hartfield 1993; Brim Box and Mossa 1999). Negative effects associated with gravel mining include stream channel modifications (altered habitat, disrupted flow patterns, sediment transport), water quality modifications (increased turbidity, reduced light penetration, increased temperature), macroinvertebrate population changes (elimination), and changes in fish populations, resulting from adverse effects to spawning and nursery habitat and food web disruptions (Kanehl and Lyons 1992). Hillside rock mining also is common in the Middle Fork watershed (Davidson pers. comm. 2021).

Chemical Contaminants – Chemical contaminants are ubiquitous in the environment and a major threat in the decline of mussel species (Richter et al. 1997; Strayer et al. 2004; Wang et al. 2007; Cope et al. 2008). Chemicals enter rivers through point and nonpoint discharges including spills, industrial and municipal effluents, and residential and agricultural runoff. These sources contribute organic compounds, heavy metals, nutrients, pesticides, and a wide variety of newly emerging

contaminants such as pharmaceuticals to the aquatic environment. These contaminants can degrade water and sediment quality to an extent resulting in adverse effects to mussel populations.

The primary routes of exposure to contaminants for adult Speckled Pocketbook are surface water, sediment, interstitial (pore) water, and diet; adults can be exposed when either partially or completely burrowed in the substrate (Cope et al. 2008). There is a lack of information on toxicant response(s) for Speckled Pocketbook.

There are three National Pollutant Discharge Elimination System (NPDES) permits issued in the extant range of Speckled Pocketbook (www.adeq.state.ar.us). The Clean Water Act authorizes the NPDES permit program, which the State manages. The threat from industrial and municipal discharges is restricted to the Middle Fork and is not a substantive threat at this time.

Agriculture, timber harvest, and lawn management practices utilize nutrients, pesticides, and herbicides. These two broad categories of chemical contaminants have the potential to affect mussel species. Nutrients, such as nitrogen and phosphorus, primarily occur in runoff from livestock farms, feedlots, heavily fertilized row crops and pastures (Peterjohn and Correll 1984), post timber management activities, and urban and suburban runoff, including leaking septic tanks, and residential fertilizers. Effects of nutrient runoff, such as increased filamentous algae, has been documented at several sites in the Middle Fork (Davidson pers. comm. 2021), but is considered a threat to Speckled Pocketbook rangewide.

e. Other natural and manmade factors affecting its continued existence

Population Fragmentation and Isolation – Population fragmentation and isolation prohibit the natural interchange of genetic material between populations. Most of the remaining Speckled Pocketbook populations are small and geographically isolated, and, thus, are susceptible to genetic drift, inbreeding depression, and changes to their environment (Smith 1990; Avise and Hamrick 1996). Inbreeding depression can result in early mortality, decreased fertility, smaller body size, loss of vigor, reduced fitness, and various chromosome abnormalities (Smith 1990). A species' vulnerability to extinction increases when they are patchily distributed due to habitat loss and degradation (Noss and Cooperrider 1994; Thomas 1994). Although changes in the environment may cause populations to fluctuate naturally, small and low-density populations are more likely to fluctuate below a minimum viable population size (the minimum or threshold number of individuals needed in a population to persist in a viable state for a given interval) (Shaffer 1981; Shaffer and Samson 1985; Gilpin and Soulé 1986). Furthermore, this level of isolation makes natural repopulation of any extirpated population unlikely without human intervention. Population isolation prohibits the natural interchange of genetic material between populations, and small population size reduces the reservoir of genetic diversity within populations, which can lead to inbreeding depression (Avise and Hambrick 1996).

Speckled Pocketbook was once widespread throughout its range with few natural barriers to prevent migration (via fish host species) among suitable habitats. However,

construction of Greers Ferry Reservoir extirpated the Little Red River population and isolated others. The host fish are widespread in both the rivers and reservoir, but we do not expect much, if any, exchange of genetic diversity among the four forks. However, ongoing genetics research will provide further information regarding whether contemporary isolation since reservoir construction is reducing genetic diversity. Recruitment reduction or failure is a potential problem for many small Speckled Pocketbook populations, a potential condition exacerbated by its reduced range, increasingly small populations, and increasingly isolated populations.

The likelihood is high that some Speckled Pocketbook populations are below the effective population size (EPS– the number of individuals in a population contributing offspring to the next generation), based on restricted distribution and populations only represented by a few individuals. Achieving the EPS is necessary for a population to adapt to environmental change and maintain long-term viability. Extirpation occurs in isolated populations when population size drops below the EPS or threshold level of sustainability (Soulé 1980). Evidence of recruitment in many Speckled Pocketbook populations is scant, making recruitment reduction or outright failure suspect. These populations may be experiencing the bottleneck effect of not attaining the EPS. Small, isolated, less than EPS–threshold populations of short-lived species (most fish hosts) theoretically die out within a decade. Without genetic interchange, small, isolated populations could be slowly expiring (Tilman et al. 1994). Even given the absence of existing or new anthropogenic threats, disjunct populations may be lost due to current below-threshold effective population size. Additionally, evidence indicates that general habitat degradation continues to decrease habitat patch size, further contributing to the decline of Speckled Pocketbook populations.

Temperature – Impoundments, tail water releases from dams, industrial and municipal effluents, changes in riparian habitat, and droughts can alter natural temperature regimes. Exact critical thermal limits for Speckled Pocketbook survival and normal physiological functions are unknown, but closely related species are classified as thermally sensitive (e.g., *Lampsilis cardium* and *L. teres*; Spooner and Vaughn 2008). However, high temperatures can reduce dissolved oxygen concentrations in the water, which slows growth, reduces glycogen stores, impairs respiration, and may inhibit reproduction (Fuller 1974). Water temperature increases shorten the period of glochidial encystment, reduce righting speed (various reflexes that tend to bring the body into normal position in space and resist forces acting to displace it out of normal position), increase oxygen consumption, and slow burrowing and movement responses (Fuller 1974; Bartsch et al. 2000; Watters et al. 2001; Schwalb and Pusch 2007). Several studies have documented the influence of temperature on the timing aspects of mussel reproduction (Gray et al. 2002; Allen et al. 2007; Steingraeber et al. 2007). Peak glochidial releases are associated with water temperature thresholds that can be thermal minimums or maximums, depending on the species (Watters and O'Dee 2000). Alterations in stream temperature regimes associated with channel widening, riparian tree canopy removal, and climate change may affect Speckled Pocketbook biological processes.

Climate Change – Small population size and limited distribution of the Speckled Pocketbook make it more vulnerable to drought, severe storm events, and other potential effects of climate change. There is growing concern that climate change may lead to increased frequency of severe storms and drought (Cook et al. 2004). The number of very warm nights (>75°F) has generally been above average for Arkansas since 1995 (https:statesummaries.ncics.org/ar). A rise in number of very warm nights may increase water temperature and result in detrimental effects described above.

Data for the Kiamichi River in southeast Oklahoma suggests that, over a 17-year period as water and air temperatures increased, mussel beds once dominated by thermally sensitive species are now dominated by thermally tolerant species (Galbraith et al. 2010; Spooner and Vaughn 2008). As temperature increases due to climate change throughout the range of Speckled Pocketbook, it may experience population declines as warmer rivers are more suitable for thermally tolerant species.

3. Conservation measures

During the past decade, numerous conservation partners in state and federal agencies, academia, and non-governmental organizations dedicated resources to a variety of Speckled Pocketbook conservation efforts. We categorized these efforts into population monitoring, captive propagation, research, and habitat and water quality improvements.

Population Monitoring - The AGFC and Service survey the four forks of the Little Red River at a 6- to 7-year interval. Continued population monitoring will be essential to the recovery of Speckled Pocketbook.

Propagation – The Service and AGFC developed cage culture facilities at Greers Ferry Reservoir for culture of Speckled Pocketbook (Moles pers. comm. 2018). In 2019, the AGFC and Service stocked 112 individuals at four sites in the Middle Fork. In 2020, they harvested 1,882 juveniles from Archey Fork brood. Of these individuals, they stocked 394 at 11 sites in Archey Fork. The remaining 1,400 individuals were left in cages to overwinter and grow more prior to additional releases in Archey Fork (~100 individuals at one additional site) and reintroduction in Big Creek planned for 2021. Brood from the South Fork will be collected in spring 2021 with subsequent stockings planned for the South Fork in the fall of 2021 and summer 2022.

Research – Past research efforts with Speckled Pocketbook focused on life history (Winterringer 2003) and genetics (Harris et al. 2004, Harris et al. 2010). The AGFC and Service funded a genetic and effective population size study that will inform long-term propagation efforts. TNC has been instrumental in developing comprehensive data sets on the condition of unpaved roads and stream bank erosion in the upper Little Red River basin. This information is critical to helping natural resource agencies and organizations focus limited funds in areas with the greatest potential to reduce sedimentation.

Habitat and Water Quality Improvement – State agencies and the Service review projects potentially affecting Speckled Pocketbook and make recommendations to minimize and mitigate for adverse effects.

In 2012, TNC completed an unpaved roads inventory (660 miles) for the four forks of the Little Red River. Various GIS indices were generated that expressed a relative scale of likely sediment production on the road segment, sediment delivery from the segment to nearby streams, and direct effect of sediment delivery to habitat for Speckled Pocketbook. Following road inventory and assessment, TNC prioritized road segments as maintenance work sites. (Inlander and Gallipeau 2012).

The Arkansas Unpaved Roads Program, created by Act 898 of the 90th General Assembly, is designed to create a better unpaved county road system with reduced negative environmental effects on priority water resources in Arkansas. The Program focuses on best management practices (BMPs) that reduce the effect of sediment and road runoff to streams, rivers, and drinking water supplies while reducing long term unpaved county road maintenance costs. During the past several years, numerous unpaved road projects have targeted high sediment delivery road segments in the South and Middle forks (Davidson pers. comm. 2021). Sedimentation from unpaved roads continues to threaten Speckled Pocketbook and its habitat, but efforts such as the Arkansas Unpaved Roads Program and other similar efforts on private unpaved roads demonstrates progress towards alleviating this threat.

There are approximately 331 individuals, corporations, or entities that collectively own approximately 87,000 acres adjacent to the four forks of the Little Red River. During the past decade, TNC acquired fee title on 980 acres and easements on 35 acres adjacent to the Archey Fork, protecting approximately four miles of river. They also acquired fee title on 909 acres and easements on 275 acres adjacent to South Fork and Butter Creek, a tributary, protecting four miles on both river sides and 0.3 mile on one side. In the Middle Fork watershed, including Meadow and Lost creeks, they acquired fee title for 1,632 acres protecting 2.7 miles on both sides of the Middle Fork, 0.3 mile on one side, and 2.8 miles on both sides of the two tributaries. Within their Archey Fork and South Fork properties, they planted 570 acres of riparian trees. BHP Billiton's donation of $6 million to advance conservation in the Little Red River watershed made many of these acquisitions possible. TNC reforested some pastureland on their preserves in partnership with Southwestern Energy's ECH$_2$O program.

In fiscal year 2016, NRCS awarded TNC $816,000 under the Regional Conservation Partnership Program to address water quality degradation and inadequate habitat for fish and wildlife in the upper Little Red River watershed through reduction of erosion, sedimentation, and excess nutrient runoff. TNC also implemented multiple stream restoration and road improvement projects in the watershed to reduce sedimentation.

Forestry best management practices (BMPs) are voluntary in Arkansas. However, BMPs are required for third party certified landowners and landowners that supply wood to mills with third party certified fiber sourcing. Certification provides BMP implementation certainty for fiber sourcing from small to large, private forestlands within the Speckled Pocketbook range. Based on Arkansas Department of Agriculture - Forestry Division reports on BMP compliance (*Best Management Practices, Water Quality - Arkansas Department of Agriculture*), compliance rates are high in Arkansas. A large body of scientific literature confirms that properly implemented BMPs and the

appropriate suite of BMPs for site-specific conditions and activities are effective at protecting water quality in actively managed forests.

D. Synthesis

The status of Speckled Pocketbook has declined since listing. Speckled Pocketbook remains threatened by a variety of land use practices that contribute sediment, nutrients, and other pollutants to the rivers, which may be exacerbated by climate change. The current distribution of this narrow-ranging endemic of the Little Red River basin is currently restricted to five rivers in Arkansas. Threats still occur throughout the species' range and recent population declines underscore the vulnerability of each isolated population to potential catastrophic events. While numerous conservation efforts are underway to reverse the decline, the current federal status of endangered remains appropriate. Substantive progress in the past two years on cage culture shows promise at reversing population declines and increasing abundance and distribution in coming years, buying time for other conservation initiatives to minimize threats and improve habitat in the watershed. Given the existing threats and conditions of the populations described above, we believe the Speckled Pocketbook still meets the definition of endangered under the Endangered Species Act.

III. RESULTS

A. Recommended Classification:

__X___ No change necessary

IV. RECOMMENDATION FOR FUTURE ACTIONS

1. Continue to implement future actions identified in the 2015 5-year review, except where otherwise specified below.

2. Remove #2 – the recovery plan was amended in 2019.

3. Number 4 is ongoing. Arkansas State University and Miami University will determine genetic variation within and among populations and determine effective population size.

4. Remove #9 – Big Creek was surveyed in 2019.

5. Determine sediment deposition rates vs. survivorship of Speckled Pocketbook.

V. REFERENCES

Allen, D.C., B.E. Sietman, D.E. Kelner, M.C. Hove, J.E. Kurth, J.M. Davis, J.L. Weiss & D.J. Hornbach. 2007. Early life-history and conservation status of *Venustaconcha ellipsiformis* (Bivalvia, Unionidae) in Minnesota. American Midland Naturalist 157:74-91.

Avise, J. C., and J. L. Hamrick, eds. 1996. Conservation genetics: case histories from nature. Chapman and Hall, New York.

Bartsch, M. R., D. L. Waller, W. G. Cope & S. Gutreuter. 2000. Emersion and thermal tolerances of three species of unionid mussels: survival and behavioral effects. Journal of Shellfish Research 19:233-240.

Brim-Box, J.B. & J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of North American Benthological Society 18:99-117.

Clarke, A.E. 1987. Status survey of *Lampsilis streckeri* Frierson (1927) and *Arcidens wheeleri* (Ortmann and Walker 1912). A report to the U. S. Fish and Wildlife Service. 24pp. plus field notes.

Cook, E.R., Woodhouse, C.A., Eakin, C.M., Meko, D.M., Stahle, D.W. 2004. Long-term aridity changes in the Western United States. Science 306, 1015–1018.

Cope, W. G., M. R. Bartsch, and R. R. Hayden. 1997. Longitudinal patterns in abundance of the zebra mussel (*Dreissena polymorpha*) in the Upper Mississippi River. Journal of Freshwater Ecology 12:235–238.

Cope, W.G., R.B. Bringolf, D.B. Buchwalter, T.J. Newton, C.G. Ingersoll, N. Wang, T. Augspurger, F.J. Dwyer, M.C. Barnhart, R.J. Neves & E. Hammer. 2008. Differential exposure, duration, and sensitivity of unionoidean bivalve life stages to environmental contaminants. Journal of North American Benthological Society 27:451-462

Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17:29-42.

Ficke, A.A., C.A. Myrick & L.J. Hansen. 2005. Potential impacts of global climate change on freshwater fishes. World Wide Fund for Nature, Gland, Switzerland.

Ficke, A.A., C.A. Myrick & L.J. Hansen. 2007. Potential impacts of global climate change on freshwater fisheries. Rev. Fish. Biol. Fisheries 17:581-613.

Fuller, S.L.H. 1974. Clams and mussels (Mollusca: Bivalvia). Pp. 215-273 *in*: C.W. Hart, Jr., and S.L.H. Fuller, eds. Pollution ecology of freshwater invertebrates. Academic Press, New York.

Galbraith, H.S., D.E. Spooner, and C.C. Vaughn. 2010. Synergistic effects of regional climate patterns and local water management on freshwater mussel communities. Biological Conservation 143:1175-1183.

Gilpin, M. E. and M. E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in M.E. Soulé, editor. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Gray, E.V.S., W.A. Lellis, J.C. Cole & C.S. Johnson. 2002. Host identificaiton for *Strophitus undulatus* (Bivalvia: Unionidae), the Creeper, in the Upper Susquehanna River Basin, Pennsylvania. Am. Midl. Nat. 147:153-161.

Harris, J.L. 1985. Search for *Lampsilis streckeri* Frierson in the forks of the Little Red River at Clinton, Arkansas. Unpubl. report. 6pp.

Harris, J.L. 1991. Survey for *Lampsilis streckeri* in the Midle Fork Little Red River at the proposed NOARK pipeline crossing, Van Buren County, Arkansas. Prepared for ENSR Consulting and Engineering, Houston, TX. 10pp.

Harris, J.L. 1992a. Temporary relocation of the Speckled Pocketbook (Lampsilis streckeri) at the NOARK pipeline crossing, Middle Fork Little Red River, Van Buren County, Arkansas. Prepared for ENSR Consulting and Engineering, Houston, TX. 10pp. + appendix.

Harris, J.L. 1992b. Status of *Lampsilis streckeri* in segments of the Middle, South, and Archey forks of the Little Red River, Stone and Van Buren counties, Arkansas. Prepared for the U. S. Fish and Wildlife Service, Endangered Species Office, Jackson, MS. 23pp. + field notes.

Harris, J.L. 1993. Habitat characterization and species associates of the speckled pocketbook (Lampsilis streckeri) in the Middle Fork Little Red River, Arkansas. Prepared for the U. S. Fish and Wildlife Service, Endangered Species Office, Jackson, MS. 28pp. plus appendices.

Harris, J.L., W.R. Hoeh, A.D. Christian, J. Walker, J.L. Farris, R.L. Johnson, and M.E. Gordon. 2004. Species limits and phylogeography of Lampsilinae (Bivalvia: Unionida) in Arkansas with emphasis on species of *Lampsilis*. Prepared for Arkansas Game and Fish Commission and U. S. Fish and Wildlife Service. 61 pp. + appendix.

Harris, J.L., A.D. Christian, and W.R. Hoeh. 2010. Hidden diversity in Arkansas freshwater mussels: description of new species and new genera with determination of species ranges for members of the genus *Lampsilis* (Bivalvia: Unionida). Unpubl. Report submitted to Arkansas Game and Fish Commission, Little Rock, AR. 31pp. + appendices.

Hartfield, P. W. 1993. Headcuts and their effect on freshwater mussels. Pp. 131-141 in: K. S. Cummings, A. C. Buchanan, and L. M. Koch, eds. Conservation and Management of Freshwater Mussels. Proceedings of a Upper Mississippi River Conservation Committee (UMRCC) Symposium, October 1992, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Kanehl, P. & J. Lyons. 1992. Impacts of in-stream sand and gravel mining on stream habitat and fish communities, including a survey on the Big Rib River, Marathon County, Wisconsin. Wisconsin Department of Natural Resources Research Report 155. 32pp.

Layzer, J. B., M. E. Gordon, and R. M. Anderson. 1993. Mussels: the forgotten fauna of regulated rivers. A case study of the Caney Fork River. Regulated Rivers: Research and Management 8:63–71.

Neves, R.J., A.E. Bogan, J.D. Williams, S.A. Ahlstedt & P.W. Hartfield. 1997. Status of aquatic mollusks in the southeastern United States: a downward spiral of diversity. Pp. 43-85 *in*: G. W. Benz and D.E. Collins, eds. Aquatic fauna in peril: the southeastern perspective, March-April 1994, Chattanooga, Tennessee. Special Publication 1, Southeast Aquatic Research Institute, Chattanooga.

Noss, R. F. and A. Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Washington, D.C. 421 pp.

Peterjohn, W.T. & D. Correll. 1984. Nutrient Dynamics in an Agricultural Watershed: Observations on the Role of a Riparian Forest. Ecology 65: 1466-1475.

Pringle, C. M., M. C. Freeman, and B. J. Freeman. 2000. Regional effects of hydrologic alterations on riverine macrobiota in the new world: Tropical-temperate comparisons. Bioscience 50:807–823.

Richter, B.D., D.P. Braun, M.A. Mendelson & L.L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081-1093.

Schwalb, A N. & M.T. Pusch. 2007. Horizontal and vertical movements of unionid mussels in a lowland river. Journal of the North American Benthological Society 26:261-272.

Shaffer, M.L. 1981. Minimum Population Sizes for Species Conservation. BioScience 31:131–134.

Shaffer, M. L., and F. B. Samson. 1985. Population Size and Extinction: A Note on Determining Critical Population Sizes. The American Naturalist 125:144.

Smith, L. S. 1990. Ecology and field biology, 4th ed. Harper and Row. 720 pp.

Spooner, D.E. & C.C. Vaughn 2008. A trait-based approach to species' roles in stream ecosystems: climate change, community structure, and material cycling. Oecologia 158:307–317.

Steingraeber, M.T., M.R. Bartsch, J.E. Kalas & T.J. Newton. 2007. Thermal Criteria for Early Life Stage Development of the Winged Mapleleaf Mussel (*Quadrula fragosa*). American Midland Naturalist 157:297–311.

Strayer, D. L., J.A. Downing, W.R. Haag, T.L. King, J.B. Layzer, T.J. Newton & S.J. Nichols. 2004. Changing perspectives on pearly mussels, North America's most imperiled animals. BioScience 54:429-439.

Inlander, E. and C. Gallipeau. 2012. Inventory, assessment, and prioritization for unpaved roads and stream crossings in the upper Little Red River watershed, Ozarks ecoregion, Arkansas.

Unpubl. report submitted to U.S. Fish and Wildlife Service, Arkansas Ecological Services Field Office. Grant Agreement Number 401817G06. 33pp. + appendices.

Thomas, C. D. 1994. Extinction, colonization, and metapopulations: Environmental tracking by rare species. Conservation Biology 8:373–378.

Tilman, D., R. M. May, C. L. Lehman, and M. A. Nowak. 1994. Habitat destruction and the extinction debt. Nature 371:65–66.

U.S. Fish and Wildlife Service. 2015. Speckled Pocketbook (*Lampsilis streckeri* Frierson 1927) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service Southeast Region, Atlanta, GA. 20pp.

U.S. Fish and Wildlife Service. 2019. Amendment to the Speckled Pocketbook (*Lampsilis streckeri*) recovery plan. U.S. Fish and Wildlife Service Southeast Region, Atlanta, GA. 11pp.

Wang, N., T. Augspurger, M.C. Barnhart, J.R. Bidwell, W.G. Cope, F.J. Dwyer, S. Geis, I.E. Greer, C.G. Ingersoll, C.M. Kane, T.W. May, R.J. Neves, T.J. Newton, A.D. Roberts & D.W. Whites. 2007. Intra- and interlaboratory variability in acute toxicity tests with glochidia and juveniles of freshwater mussels (Unionidae). Environmental Toxicity and Chemistry 26:2029-2035.

Watters, G. T. 2000. Three year freshwater mussel life requirement investigation. Unpublished report, Ohio State University, Columbus, for The Fish Creek Trust Committee. 4 pp.

Watters, G. T., and C. J. Myers Flaute. 2010. Dams, zebras, and settlements: The historical loss of freshwater mussels in the Ohio River mainstem. American Malacological Bulletin 28:1–12.

Watters, G.T. & S.H. O'Dee. 2000. Glochidial release as a function of water temperature: Beyond bradyticty and tachyticty. Pp. 135-140 *in:* R.A. Tankersley *et al.,* eds. Proceedings of the Conservation, Captive Care, and Propagation of Freshwater Mussels Symposium, 1998. Ohio Biological Survey Special Publications, Columbus, Ohio.

Watters, G.T., S.H. O'Dee & S. Chordas III. 2001. Patterns of Vertical Migration in Freshwater Mussels (Bivalvia: Unionoida), Journal of Freshwater Ecology, 16(4):541-549.

Winterringer, R. 2003. Population dynamics and reproductive patterns of the federally endangered freshwater mussel, *Lampsilis streckeri* (Frierson 1927). M.S. thesis. Arkansas State University, State University, Arkansas. 74pp.

VI. PEER REVIEW

We received one public comment letter during the public comment period and incorporated those comments where appropriate. We maintain a record of all public comments and responses in the administrative record for this review. We have not received significant new information since the last status review and the level of public interest is low and non-controversial. Therefore, we did not conduct peer review.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
Speckled Pocketbook (*Lampsilis streckeri*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change is needed

Review Conducted By: Chris Davidson, USFWS Arkansas Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve MELVIN TOBIN Digitally signed by MELVIN TOBIN Date: 2021.09.07 08:01:32 -05'00' Date_____

OTHER REGIONAL OFFICE APPROVAL: None required (Arkansas endemic)