

**Shiny Pigtoe**  
*Fusconaia cor*

**5-Year Review:  
Summary and Evaluation**

**U.S. Fish and Wildlife Service  
Southeast Region  
Asheville Ecological Services Field Office  
Asheville, North Carolina**

**5-YEAR REVIEW**  
**Shiny pigtoe (*Fusconaia cor*)**

**I. GENERAL INFORMATION**

**A. Methodology used to complete the review**

This 5-year status review was completed by the species' recovery lead biologist in the U.S. Fish and Wildlife Service's (USFWS) Asheville, North Carolina Ecological Services Office. A *Federal Register* notice announcing the review and requesting information was published on July 28, 2006 (71 FR 42871) and a 60-day comment period was opened. No significant new information was received in response to the notice. Our sources of information for this 5-year review include the final rule listing this species under the Endangered Species Act (Act), the Recovery Plan (USFWS 1984), peer reviewed scientific publications, unpublished reports, and information and communications from qualified biologists or experts. No part of this review was contracted to an outside party. This review also underwent peer review by three experts familiar with the species (see Appendix A). Comments received were evaluated and incorporated as appropriate.

**B. Reviewers**

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**Cooperating Field Office** – Abingdon, Virginia, Ecological Services: Shane Hanlon (276) 623–1233 Ext. 25

**C. Background**

1. **Federal Register Notice citation announcing initiation of this review:**  
July 28, 2006: 71 FR 42871
2. **Species status:** Stable
3. **Recovery achieved:** 1 (1=0-25% recovery objectives achieved)

**4. Listing history**

Original Listing

FR notice: 41 FR 24062

Date listed: June 14, 1976

Entity listed: species

Classification: endangered

**5. Associated rulemakings:**

72 FR 52434; September 13, 2007; Establishment of Nonessential Experimental Population Status for 15 Freshwater Mussels, 1 Freshwater Snail, and 5 Fishes in the Lower French Broad River and in the Lower Holston River, Tennessee.

66 FR 43808; August 21, 2001; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free-Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, Alabama. Correction.

66 FR 32250; June 14, 2001; Establishment of Nonessential Experimental Population Status for 16 Freshwater Mussels and 1 Freshwater Snail (Anthony's Riversnail) in the Free Flowing Reach of the Tennessee River below the Wilson Dam, Colbert and Lauderdale Counties, Alabama.

**6. Review History:**

Final Recovery Plan: 1984

A previous 5-year review for this species was noticed on November 6, 1991 (56 FR 56882). In that review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors, threats, etc. as they pertained to the individual species. In particular, no changes were proposed for the status of this species in that review.

Recovery Data Call: 2011, 2010, 2009, 2008, 2007, 2006, 2005, 2004, 2003, 2002, 2001, and 2000

**7. Species' Recovery Priority Number at start of review (48 FR 43098):**

5. This number indicates a species with a high degree of threat and a low recovery potential.

**8. Recovery Plan**

Name of plan: Recovery Plan [for the] Shiny Pigtoe Pearly Mussel (*Fusconaia edgariana*) [= *Fusconaia cor*]

Date issued: July 9, 1984

## II. REVIEW ANALYSIS

### A. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable.

### B. Recovery 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? Yes**
  - b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? Yes**
3. **List the recovery criteria as they appear in the Recovery Plan, and discuss how each criterion has or has not been met, citing information.**

The shiny pigtoe will be considered for delisting when the following criteria are met:

1. A population of *Fusconaia cor*, with evidence of recent recruitment (specimens age 5 or younger), exists in (a) North Fork Holston River above Saltville (NFHRM 85.0), Smyth County, VA, (b) Clinch River from the backwaters of Norris Reservoir, TN, upstream to Nash Ford (CRM 280), Russell County, VA, (c) Powell River from the backwaters of Norris Reservoir, TN, upstream to Flanary Bridge (PRM 130), Lee County, VA, (d) Elk River in Lincoln County, TN, (e) Paint Rock River in Jackson County, AL, and (f) Copper Creek, Scott County, VA. These populations are distributed widely enough within their rivers such that it is unlikely a single adverse event in a river would result in the total loss of that population.
  - *viable population* – a reproducing population that is large enough to maintain sufficient genetic variation to enable it to evolve and respond to natural habitat changes. Determining

the number of individuals needed to meet this definition is one of the recovery tasks.

- *population center* – a single shoal or grouping of shoals which contain *Fusconaia cor* in such close proximity that they can be considered as belonging to a single breeding unit.

Five shiny pigtoe populations occurred at the time the 1984 Recovery Plan was written. These included Clinch (including a tributary, Copper Creek), Powell, North Fork Holston, Paint Rock, and Elk Rivers. The Copper Creek population is confined to lower reaches of that stream and likely contiguous with and dependent upon the Clinch River population for sustainability.

The Clinch River drainage population has declined since the 1980s, particularly in Virginia, but has improved in recent years. This population is distributed along a total of about 80 river miles (RMs), and in addition to the lowermost reaches of Copper Creek and Little River, continues to exhibit evidence of recruitment, and represents the best population rangewide. The species persists in Powell River although it has declined in abundance since the 1980s and there has been no evidence of recent recruitment. The North Fork Holston River population of the shiny pigtoe, although limited to a relatively short reach, remained sizable until about 2000 when it was decimated by a dieoff of unknown cause, and is now rare there. The Paint Rock River population has also declined in recent decades but continues to recruit at a low level. The shiny pigtoe is likely extirpated from Elk River since it was last reported live in 1990.

Continuing threats from a suite of stressors—coal mining, urbanization, agriculture, and toxic chemical spills—may compromise the continued existence of the shiny pigtoe throughout its range. USFWS is working with researchers and natural resource managers at Virginia Polytechnic Institute and State University (VPI), Virginia Department of Game and Inland Fisheries (VDGIF), Virginia Department of Mines, Minerals, and Energy (VDMME), Tennessee Wildlife Resources Agency (TWRA), Alabama Department of Conservation and Natural Resources (ADCNR), U.S Geological Survey (USGS), Office of Surface Mining (OSM), Tennessee Valley Authority (TVA), The Nature Conservancy (TNC), and other partners to reduce pollutants in streams and improve the status of the species.

In order to recover the shiny pigtoe in the upper Tennessee River drainage, it will be necessary to augment existing populations and to reintroduce the species into appropriate habitat within its historical range. It is imperative that propagation technology be developed for the species. Extant populations are too small to allow direct translocation of adult animals to accomplish these goals. It may take several years to develop culture technology for the shiny pigtoe before augmentation and reintroduction efforts could even be attempted.

Other primarily habitat-related issues must also be addressed before recovery can progress. In Elk River, a recent agreement between TVA and USFWS seeks to improve tailwater conditions (e.g., thermal, oxygen, flow regimes) below Tim's Ford Dam. Some early success has been demonstrated with reintroducing hatchery propagated federally listed mussels into Elk River, but the shiny pigtoe is not currently one of them. Survival has been excellent and they appear to be growing. Population augmentation in Powell River in all but a limited reach in Tennessee may be futile unless coal mining issues in that watershed are addressed and ameliorated and habitat conditions improve to the point where the shiny pigtoe can successfully reproduce and recruit without human intervention. Habitat conditions in Clinch and Paint Rock Rivers appear to be suitable (based on the status of other mussel species) to make population expansion and augmentation in these streams a viable recovery option if cultured individuals could be produced. If the shiny pigtoe population in Clinch River can be improved through augmentation efforts, the species in Copper Creek would likely benefit.

2. Through re-establishments and/or discoveries of new populations, a viable population exists in one additional river or two river corridors which historically contained the species. The river (corridors (or parts of a river where the mussel was historically found)) will contain at least two population centers which are dispersed to the extent that a single adverse event would be unlikely to eliminate *Fusconaia cor* from its re-established location. For a re-established population, surveys must show that three year-classes, including one year-class of age 10 or older, have been naturally produced within each of the population centers.

This species is included in a Non-essential Experimental Population (NEP) designation for 16 mussels and 1 snail in the reach of Tennessee River below TVAs Wilson Dam in Colbert and Lauderdale Counties, Alabama. Currently, no individuals of this species have been reintroduced at this location. In addition, another multi-species NEP has been published that includes this species in the lower portions of French Broad and Holston Rivers in Knox County, Tennessee, where tailwater conditions (e.g., thermal, oxygen, flow regimes) continue to be improved for the species and its host fishes (typically shiners). Until culture technology is developed, however, it is unlikely that sustainable experimental populations of the shiny pigtoe can be created in these NEPs. Nolichucky, upper Holston, and Pigeon Rivers have also been identified by regional mussel managers as possible reintroduction streams for this species. USFWS is working with TVA, ADCNR, TWRA, and other partners to improve tailwater habitat for mussels and host fishes (e.g., thermal, oxygen, flow regimes) below TVA impoundments. No previously unknown populations of the shiny pigtoe have been discovered for several decades.

3. The species and its habitats are protected from present and foreseeable anthropogenic and natural threats that may interfere with the survival of any of the populations.

Some limited progress has been made regarding this criterion; however, we do not anticipate meeting this criterion in the near future. USFWS is working with VPI, VDGIF, VDMME, TWRA, ADCNR, USGS, OSM, TVA, TNC, and other partners to improve the status of the shiny pigtoe throughout its range. There are projects in most streams of current occurrence that are intended to repair and restore streambanks, riparian areas, and instream habitats, as well as reduce contaminants from upland activities. These efforts have provided protection to shiny pigtoe habitat and reduced runoff in their watersheds.

4. Noticeable improvements in coal-related problems and substrate quality have occurred in the Powell River, and no increase in coal or other energy-related impacts exists in the Clinch River.

Noticeable improvements in coal-related problems and substrate quality in Powell River are not readily identifiable over the past two decades. However, a limited reach in Tennessee has improved habitat quality. In Clinch River, an upper reach from Carbo to Nash Ford in Virginia has also shown signs of improvement in substrate and water quality, and mussel and fish densities appear to be increasing. In addition, the reach downstream from Carbo to the confluence with Lick Creek is showing signs of faunal recovery from catastrophic toxic spills around 1970 at a coal-fired power plant and chronic release of pollutants from the power plant and nearby coal mining activities. The shiny pigtoe and threatened yellowfin madtom have recently been rediscovered in this reach, and newly-recruited individuals of common mussel species have also been observed there.

Although the production of coal in Virginia has declined by more than half since 1990 according to VDMME, it is anticipated that coal and particularly natural gas production looking forward may reverse that trend based on current energy demands, human population growth, and a hybrid energy power plant that is nearing completion on upper Clinch River in Virginia. Therefore, impacts from these activities may continue for the foreseeable future. The Virginia and Southwest Virginia Field Offices of USFWS are working with VDMME, OSM, coal mining and natural gas extraction interests, and other partners to better protect habitat for Clinch and Powell River shiny pigtoe populations from these activities.

## **C. Updated Information and Current Species Status**

### **1. Biology and Habitat**

#### **a. Abundance, population trends, demographic features, or demographic trends:**

**Clinch River, Virginia and Tennessee:** The shiny pigtoe was considerably more common in Clinch River as recently as the early 1980s but was starting to show signs of decline by the end of the decade. Since then it has become much more uncommon. Systematic mussel surveys conducted on Clinch River over the past 30 years by TVA, VDGIF, VPI, and other biologists indicated that the species continued to decline until recent years. Approximately every five years since 1979, a varying number of sites (6–15) have been surveyed for mussels using quantitative (0.25 m<sup>2</sup> quadrats) and qualitative methods (Ahlstedt and Tuberville 1997, Ahlstedt et al. 2005, Jones et al. in press). Numbers of live shiny pigtoe varied from zero in 1988 (348 quadrats sampled at 11 sites) and 1999 (227 quadrats sampled at 6 sites) to nine individuals in 1994 (428 quadrats sampled at 14 sites). Annual sampling at three sites in Tennessee from 2004–2009 yielded seven live individuals from two sites among 1,123 quadrats sampled. A single individual was found over two sampling periods in 2004 and 2009 among 2,101 quadrats sampled at 15 sites. In recent years the decline of the shiny pigtoe in Clinch River seems to have stabilized and the population is currently thought to be improving, although it continues to be rare. Since 2000, low numbers of individuals have regularly been located during periodic sampling efforts, particularly in the Tennessee portion of the river, and recent recruitment is evident. The species occurs sporadically in a total of about 80 river miles (RMs) of the Clinch River mainstem in two disjunct reaches—the upper river in eastern Russell County, Virginia (~50 RMs) and the lower river in Hancock County, Tennessee (~30 RMs)—separated by a mussel “dead zone” caused by various pollution sources (Jones et al. in press). Despite having lost a considerable percentage of its historical abundance, the Clinch River population of the shiny pigtoe represents the largest currently remaining population (J.W. Jones, USFWS, pers. comm., 2012).

**Copper Creek, Virginia:** A portion of the Clinch River population resides in this tributary. Ten live individuals were collected at 2 of 36 sites sampled in 1980 in Copper Creek (Ahlstedt 1981). A single fresh dead specimen was found among 20 sites sampled in 1998 (Fraley and Ahlstedt 2000). A single live individual was observed among 43 sites sampled during 2003–04 (Hanlon et al. 2009). The shiny pigtoe is currently very rare in Copper Creek, and may rely on the source population in Clinch River for sustainability.

**Powell River, Virginia and Tennessee:** The shiny pigtoe population in Powell River was considered one of the best rangewide when the Recovery Plan (USFWS 1984) was written but has declined over the past 25 years. A dieoff of unknown cause was reported in 1983 by Ahlstedt and Jenkinson (1986). Approximately every five years since 1979, quantitative (quadrats) mussel sampling has been conducted at a varying number of sites (6–19); five live individuals were found in 1979 and single individuals were found in 1983 and 1988 (Ahlstedt and Tuberville 1997, Ahlstedt et al. 2005). Even common species (e.g., *Actinonaias pectorosa*) appear to be declining in Powell River based on a

decrease in subadults observed between 1978 and 1988 (Wolcott and Neves 1994). The viability of the shiny pigtoe in Powell River is becoming increasingly compromised given its current rarity. A 2008–2009 survey produced 19 live individuals from 5 of 21 sites, though no evidence of recent recruitment was detected (Johnson et al. in press). The species occurs very sporadically between RM 136–198. A limited reach in Tennessee has shown signs of improving habitat quality (J.W. Jones, USFWS, pers. comm., 2012). Recent evidence of recruitment in other imperiled mussel species (Johnson et al. in press)—particularly in this reach of the lower Powell River—provides hope that this shiny pigtoe population continues to recruit and is viable.

**North Fork Holston River, Virginia:** The upper North Fork Holston River is well-known for being productive for the shiny pigtoe and other mussel species. Despite its restriction to a relatively short reach above Saltville, this shiny pigtoe population was considered one of the largest rangewide in the Recovery Plan (USFWS 1984). This population has declined catastrophically since 2000 due to a dieoff of unknown cause, though it is possibly related to a combination of agricultural pollution and trematode infestations (W.F. Henley, VPI, pers. comm., 2006). A total of 202 live individuals were collected from 14 of 36 mainstem sites sampled from 1998–2004. The most productive site for the shiny pigtoe was RM 88.7, where 137 live individuals (1998–2000) and 114 fresh dead specimens (1999–2002) were found (some of these live individuals were possibly tallied multiple times over different years and site visits) (Jones and Neves 2007). Only a single live individual was observed at this site during a random timed search (3 person hours) conducted in 2006 indicating that the population had significantly declined since 2002 and is now rare (S.D. Hanlon, USFWS, unpublished data). The shiny pigtoe is currently restricted to an 11-mile reach (RM 84.6–95.9). The species appears to have been recruiting up to the early 2000s, and though no young individuals were located in 2006, a 23.2 mm long shiny pigtoe estimated to be 3-years old was found in 2012 (J.W. Jones, USFWS, pers. comm., 2012). Despite the population having declined substantially in recent years, it continues to exhibit evidence of viability.

**Paint Rock River, Alabama:** A small population of shiny pigtoe has persisted in this middle Tennessee River tributary. A total of 14 live individuals and 16 fresh dead specimens of shiny pigtoe were collected from 7 of 18 Paint Rock River sites surveyed in 1991 (Ahlstedt 1995–96). Their ages ranged from 4–30+ years. Four live adult individuals were found at 1 of 2 headwater sites sampled in 2002 (Godwin 2002). Five live individuals were found at 2 of 4 sites in 2004 (J. Garner, ADCNR; J. Godwin, Alabama Natural Heritage Program, pers. comm., 2004, 2006) and it was also reported live from a lower mainstem site in 2006 (M. Gangloff, Auburn University, pers. comm., 2006). During a 2008 survey, six live individuals and additional fresh dead specimens were observed at 4 of 41 sites (Fobian et al. 2008). One individual was 21 mm in length, indicating recent recruitment. The Paint Rock River population continues to be viable based on

status information gathered in recent years, but the species has declined over the past two decades.

**Elk River, Tennessee:** Thirteen live individuals of this species were collected from nine sites during a 120-mile TVA float survey of Elk River in 1980 (Ahlstedt 1983). Since then only a single live individual has been observed during a 7-RM float survey in 1990 (Hubbs et al. 1991). Subsequent survey efforts have not documented any additional live specimens or fresh dead shells of this species (e.g., 4 sites in 1997, Madison and Layzer [1998]; 16 sites in 1999, USFWS [1999]; several sites in 2000, Garner [2001]; 4 sites in 2001, Hubbs [2002]; 5 sites in 2005, Ahlstedt et al. [2006]; 3 sites in 2011, P.D. Johnson, ADCNR, pers. comm., 2011). The shiny pigtoe is now likely extirpated from Elk River (S.A. Ahlstedt, USGS retired, pers. comm., 2006).

**b. Genetics, genetic variation, or trends in genetic variation:**

No information is currently known concerning the species' population genetics. However, a project has been funded and is underway to assess a comparative genetics study of several conchologically similar upper Tennessee River drainage species, including the shiny pigtoe (J.W. Jones, USFWS, pers. comm., 2012).

**c. Taxonomic classification or changes in nomenclature:**

The specific epithet of the shiny pigtoe was *edgariana* at the time of the Recovery Plan (USFWS 1984). Since that time, the specific epithet *cor* has been determined to represent a senior synonym and be the valid name for this taxon, relegating *edgariana* to junior synonym status (Turgeon et al. 1998). This name change was made under the rules set forth in the International Code of Zoological Nomenclature.

There is a possibility that *Fusconaia cor* and the closely related and similarly endangered finereyed pigtoe, *F. cuneolus*, are merely phenotypic variants of a single taxon (J.W. Jones, USFWS, pers. comm., 2007). A taxonomic distinction study is needed to solve this issue.

**d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historical range:**

One of the five shiny pigtoe populations known at the time the Recovery Plan (USFWS 1984) was published is now considered extirpated (Elk River). The species has experienced a catastrophic decline in North Fork Holston River since the late 1990s, potentially indicating a restriction of its range there. Considerable declines have also occurred in Clinch, Powell, and Paint Rock Rivers since 1980. These losses further restrict the number of river miles currently occupied by this imperiled species and

reduce its overall abundance, making it even more susceptible to extinction. Its status has improved in recent years in Clinch River, which represents the majority of its current global range.

**e. Habitat**

Suitable habitat for the shiny pigtoe is sporadic in the middle and upper Tennessee River drainage. Impoundments and secondarily episodic and chronic toxic events have vastly reduced the amount of available habitat for the species. Some restricted habitat reaches within its historical range are considered to have improved enough to consider shiny pigtoe augmentations or reintroductions (e.g., Clinch River, Virginia; Powell River, Tennessee; Paint Rock River, Alabama). Collaborative efforts between USFWS, TVA, ADCNR, TWRA, and other partners are attempting to improve water quality conditions in certain impoundment tailwaters (e.g., Elk River). USFWS is working with VPI, VDGIF, TWRA, ADCNR, USGS, TVA, TNC, and other partners to improve habitat and water quality conditions throughout the range of the species primarily through riparian restoration projects. The Virginia and Southwest Virginia Field Offices of USFWS are working with VDMME, OSM, coal mining and natural gas extraction interests, and other partners to better protect habitat for Clinch and Powell River shiny pigtoe populations from these activities.

**f. Other**

The life history of the shiny pigtoe has been studied in North Fork Holston River, Virginia (Kitchel 1985). This species is a short-term brooder and is gravid from mid-June to early August (J.W. Jones, USFWS, pers. comm., 2012). Host fishes identified through laboratory induced and natural infestations include common (*Luxilus cornutus*), striped (*Luxilus chrysocephalus*), telescope (*Notropis telescopus*), Tennessee (*Notropis leuciodus*), warpaint (*Luxilus coccogenis*), and whitetail (*Cyprinella galactura*) shiners (Williams et al. 2008). It lives to at least 30 years.

Propagation efforts on this species are still in their infancy but it appears to be incredibly difficult to culture. Short-term brooders have very short spawning and glochidial brooding seasons. Coupled with its rarity and the tendency for gravid females to abort glochidia when disturbed, locating and successfully securing gravid broodstock is difficult. White Sulphur Springs National Fish Hatchery and VPI are among culture facilities working to develop propagation technology for short-term brooders. Their efforts should increase our level of knowledge for this species and aid in its recovery.

## 2. Five-Factor Analysis

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

The shiny pigtoe Recovery Plan (USFWS 1984) listed impoundment, siltation, and pollution as the “major causes” for the decline of this species. The Elk River population is now considered extirpated due primarily to altered flow conditions below Tim’s Ford Dam. Impacts include cold-water releases and detrimental hydropeaking flows that have destabilized banks and the stream channel, thus reducing mussel habitat primarily in the middle and secondarily lower Elk River. USFWS and its partners, (e.g., VDGIF, VDMME, TWRA, ADCNR, USGS, OSM, TVA, TNC) are working on reducing siltation and other pollutant runoff and improving stream habitat conditions throughout the range of the shiny pigtoe through various funding sources that serve to improve streambank and riparian habitats, ameliorate the effects of tailwater releases, and attempt to minimize the effects of coal mining and other activities on mussels.

Several coal mining related pollutants may have significantly affected mussel habitat in Clinch and Powell Rivers and have likely contributed to the decline of the shiny pigtoe (Price et al. 2011). Two catastrophic toxic spills occurred in the upper Clinch River, Virginia, around 1970 at a coal-fired power plant (Cairns et al. 1971, Hampson et al. 2000). In addition, chronic wastewater effluent discharge from the power plant and polluted waters from a tributary, Dump’s Creek—which is influenced by active mining, coal-processing effluent, coal ash settling pond leachate, and a coal fly ash landfill—affects this reach (Hull et al. 2006). Collectively, various pollutants in this reach have created a mussel “dead zone” (Jones et al. in press). The Powell River also has a long history of perturbations from coal mining activities. The role that coal mining has played in the decline of the mussel fauna in Powell River in Virginia was summarized by Wolcott and Neves (1990, 1994). The impacts from various coal mining activities on the aquatic fauna were reviewed by Hull et al. (2006). Mine-related pollutants that likely contributed to the decline of the shiny pigtoe (e.g., water column ammonia, arsenic and other metals in sediments) were identified by Price et al. (2011). Although they noted a general decline in these contaminants in Clinch and Powell Rivers over the past several decades, total dissolved solids continue to rise, especially in reaches of these streams where mining is still active. Research indicates that Powell River mussel populations were inversely correlated with coal fines in the substrate. When coal fines were present, decreased filtration times and increased movements were noted in laboratory-held mussels (Kitchel et al. 1981).

Although the production of coal in Virginia has declined by more than half since 1990 (VDMME 2012), it is anticipated that production of coal and particularly natural gas looking forward may reverse that trend based on current energy demands and human population growth. In fact, construction on a hybrid energy

power plant is nearing completion on upper Clinch River in Virginia. Scores of active and inactive mines are known from Virginia and five mine tailings pond spills were reported from 1995–1999 in the upper Clinch and Powell River drainages (Hampson et al. 2000). Such mines may continue to be sources of pollutants that negatively affect shiny pigtoe populations.

Researchers and managers have speculated for decades on the causes for widespread mussel declines in the eastern U.S., including losses of shiny pigtoe populations. Conducting an assessment of the many factors that have been blamed for mussel declines since the major dam construction era of the mid-1900s (e.g., sedimentation, pollutants, eutrophication), Haag (2012) speculates that pesticides and ammonia—among habitat factors—are potentially responsible for broadscale losses of the fauna. These pollutants have primarily agricultural origins, although they are also associated with developmental activities. Pesticides may adhere to sediment particles in the substrate and ammonia tends to occur at higher concentrations in interstitial benthic habitats. Both substances are thus prevalent in habitats where mussels occur, and may prove especially detrimental to the health of juveniles, which pedal feed on sediments in interstitial habitats. An emerging threat is the increasing prevalence of pharmaceutical and related substances in surface waters. Many of these chemical compounds act as endocrine disruptors in mussels and fishes that are known to alter physiological processes, especially metabolism and reproduction (Haag 2012). In rivers these compounds are most prevalent downstream of municipal wastewater outfalls and in reaches with high livestock concentrations—both being areas where ammonia concentrations also tend to be high.

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

Overutilization for commercial, recreational, scientific or educational purposes was not specifically considered to be a limiting factor in the shiny pigtoe Recovery Plan (USFWS 1984). We have no new information to indicate that this has changed.

**c. Disease or predation:**

The shiny pigtoe Recovery Plan (USFWS 1984) did not specifically discuss disease or predation as limiting factors for this species. Disease has long been suspected as a cause of mussel declines, particularly in episodic dieoffs (e.g., Neves 1986). In assessing factors that have realistically contributed to widespread declines in mussel populations, Haag (2012) suggested that disease was potentially a leading cause. However, virtually nothing is known regarding mussel diseases, making this field essentially wide open for future research.

In North Fork Holston River, the muskrat (*Ondatra zibethicus*) has been documented as an important predator of the shiny pigtoe (Neves and Odum 1989).

However, we have no new definitive information that would indicate that predation is a limiting factor in the recovery of the species at this time. The shiny pigtoe dieoff in upper North Fork Holston River may be at least partially attributed to trematode infestations that were exacerbated by some yet unknown stressor (possibly an agricultural pollutant) that may be negatively affecting mussel fitness (W.F. Henley, VPI, pers. comm., 2006).

**d. Inadequacy of existing regulatory mechanisms:**

The inadequacy of existing regulatory mechanisms was not specifically considered to be a limiting factor in the shiny pigtoe Recovery Plan (USFWS 1984). The shiny pigtoe is listed as endangered by the states of Tennessee and Virginia and protected by regulation in Alabama. Though these designations prohibit collection of the species without a valid state collecting permit, they do not provide any protection to the species from other forms of take or offer any regulatory protection to its habitat.

Many activities in the mussel's habitat occur without any coordination with the USFWS and are reviewed and regulated (if at all), only by state and local regulatory agencies for compliance with any applicable state and local regulations and ordinances<sup>1</sup>. State and local regulations and ordinances that are adequate to protect the species and its habitat from the effects of residential and commercial development activities; private road construction, maintenance, and runoff; agriculture and forestry activities, etc., are few or poorly enforced. Many of these activities in shiny pigtoe streams continue to impact the species and its habitat and potentially limit its recovery.

While we have had success through section 7 of the Act in eliminating or reducing impacts to the shiny pigtoe and its habitat from some federal activities (activities subject to section 7 of the Act, or activities that are authorized, permitted, funded, or carried out by federal agencies), we have not been successful in eliminating all of the adverse effects from these activities. Several of these activities have adversely affected the species and its habitat, at least in the short-term, and potentially limit its recovery<sup>2</sup>.

**e. Other natural or manmade factors affecting its continued existence:**

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<sup>1</sup> Unless it can be proven: (1) in a federal court of law that violation of section 9 of the Act, which prohibits the "take" of federally listed species, or other federal regulation, has occurred as a result of the activity; or, (2) that violation of section 9 will occur and a permit pursuant to section 10(a)(1)(B) of the Act is required. However, under the former scenario impact(s) to the species has (have) already occurred or is(are) occurring, and the later requires notification of the Service of the impending activity.

<sup>2</sup> Section 7 (a)(2) of the Act requires federal agencies to ensure that their activities do not "jeopardize the continued existence" of federally-listed species or "destroy or adversely modify designated critical habitat"; however, it does not prohibit federal activities that adversely affect the species, its habitat, or designated critical habitat if these affects fall below the jeopardy and/or destruction/adverse modification of critical habitat thresholds.

Rare species with small, highly disjunct populations like the shiny pigtoe may suffer various threats from inherently small population size (summarized in USFWS 2004). Limited geographic range and rarity make its populations extremely vulnerable to localized extinctions from stochastic disturbances and decreased fitness from reduced genetic diversity. Potential sources of such disturbances include accidental spills involving vehicles transporting chemicals over roadway stream crossings inhabited by the shiny pigtoe and accidental or intentional release of chemicals used in agricultural or residential applications. Impoundments, spills, and other human-induced changes are a significant threat to aquatic organisms due to the genetic concerns associated with small, geographically isolated populations. This can be especially true for a species such as the shiny pigtoe whose historical populations were connected along mainstem rivers and multiple tributaries. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and decreasing their ability to adapt to environmental changes (Allendorf and Luikart 2007).

The first major extinction wave for mussels was the direct result of the broadscale impoundment of larger rivers in the eastern U.S. (Haag 2009). A second extinction wave appears inevitable due to small populations of mussels slowly dying out due to attrition and other factors in isolated stream reaches (Haag 2012).

#### **D. Synthesis**

In summary, none of the recovery criteria for the shiny pigtoe have been met. Primary threats to the species (e.g., from coal mining, urbanization, agriculture, toxic chemical spills) remain similar to what they were in 1976 when it was listed as endangered and to what they were in 1984 when the Recovery Plan (USFWS 1984) was written. Although there have been few significant improvements regarding threats to the species rangewide, USFWS and numerous partners are working to reduce impacts from various activities detrimental to its recovery. In recent years, some restricted habitat reaches within its historical range are considered to have improved enough to consider shiny pigtoe augmentations or reintroductions (e.g., Clinch River, Virginia; Powell River, Tennessee; Paint Rock River, Alabama). Despite coal mining in Virginia having declined in recent decades, production of coal and particularly natural gas may increase due to factors such as demographic trends, energy demand, and ongoing construction of a hybrid energy power plant on upper Clinch River. All populations of the shiny pigtoe have declined since the early 1980s. One of the five shiny pigtoe populations extant at the time the Recovery Plan (USFWS 1984) was published (Elk River) is likely extirpated. Populations in Powell and Paint Rock Rivers continue to decline. The species has shown limited recruitment in Paint Rock River, but there has been no evidence of recruitment in recent years in Powell River making its viability there questionable. The once large North Fork Holston River population has also declined significantly over the past 20 years due to a dieoff of unknown causes but continues to exhibit some level of viability based on limited evidence of recent recruitment. Generally, these shiny pigtoe populations are small, linearly distributed, and reach limited, making them especially

susceptible to stochastic events, such as chemical spills. For decades the Clinch River population trended downward in status until recently improving, though it is still rare. The shiny pigtoe population in Clinch River is sporadically distributed over about 80 RMs and represents the only population that is considered sizable, displays ample evidence of recent recruitment, and is unquestionably viable. Despite the long-term decline in the status of the shiny pigtoe, we consider the overall status of the species to have been stable over the past few years, due primarily to the relatively extensive Clinch River population which now comprises a large percentage of its global abundance. In assessing all available information on the current conservation status of the shiny pigtoe, we believe it continues to meet the definition of an endangered species.

### III. RESULTS

#### A. Recommended Classification:

  x   No change is needed

### IV. RECOMMENDATIONS FOR FUTURE ACTIONS (in general order of importance)

- Develop juvenile propagation and growout technology.
- Reintroduce individuals through release of propagated juveniles and/or release of infected host fishes in other streams within the historical range (e.g., Nolichucky, upper Holston, Pigeon, and Little (Tennessee) Rivers; Tennessee River below Wilson Dam; possibly lower French Broad/Holston and Elk Rivers if thermal, oxygen, and flow regimes are corrected) that have suitable habitat and water quality conditions.
- Augment and expand extant populations through release of propagated juveniles and/or release of infected host fishes.
- Determine how much genetic variation is sufficient to maintain long term population viability.
- Determine the degree of threat (especially coal mining in Clinch and Powell Rivers) to each stream in which this species occurs.
- Determine extent and viability of all currently known populations.
- Survey for and assess populations of potential host fishes in the NEP tailwaters in Tennessee River, lower French Broad and Holston Rivers, and other potential reintroduction sites.
- Conduct a taxonomic distinctiveness study to determine the validity of this species and its relatedness to the finerayed pigtoe, *Fusconaia cuneolus*.

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**U.S. FISH AND WILDLIFE SERVICE  
5-YEAR REVIEW of Shiny pigtoe (*Fusconaia cor*)**

Current Classification: Endangered  
Recommendation resulting from the 5-Year Review

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change is needed

Review Conducted By: Bob Butler, Asheville, North Carolina Ecological Services Field Office

**FIELD OFFICE APPROVAL:**

Lead Field Supervisor, Fish and Wildlife Service

Approve  Date 8/7/12

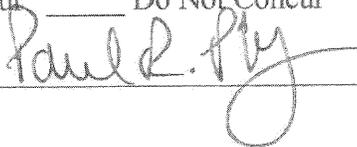
*The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.*

**REGIONAL OFFICE APPROVAL:**

Lead Regional Director, Fish and Wildlife Service

Approve  Date 10/2/12

Cooperating Assistant Regional Director, Fish and Wildlife Service

Concur  Do Not Concur  
Signature  Date 10/23/13

**APPENDIX A: Summary of peer review for the 5-year review of shiny pigtoe (*Fusconaia cor*)**

*Reviewers: A list of peer reviewers is provided above on page 20.*

**A. Peer Review Method:** A draft 5-year review of the finereyed pigtoe was sent to each of three reviewers, as an attachment to an email or via mail, requesting their review and any other changes or additions that should be included in the document. All three reviewers have extensive knowledge of this and/or similar species.

**B. Peer Review Charge:** Reviewers were charged with providing a review of the document including any other comments and/or additions they felt were appropriate to include. Reviewers were not asked to comment on the legal status of the species.

**C. Summary of Peer Review Comments/Report:** Reviewers responded by email or by mail. All reviewers did not suggest that the status of the species needed to be changed and generally thought the information in the document provided to them was accurate. They did provide some additional data, references, and recommendations for future actions that were incorporated into the 5-year review as appropriate, as well as making minor editorial corrections.

**D. Response to Peer Review:** Recommendations from the reviewers were incorporated into the document as appropriate. These consisted primarily of additional information concerning the status of certain populations, threats to the species, additional references, and recommendations for future actions.