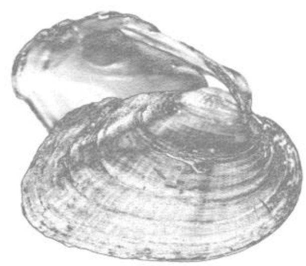
Purple Bean
(*Villosa perpurpurea*)

5-Year Review:
Summary and Evaluation



U.S. Fish and Wildlife Service
Southwestern Virginia Field Office
Abingdon, Virginia

October 2013

5-YEAR REVIEW
Purple bean/*Villosa perpurpurea*

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Methodology used to complete the review: This 5-year review, conducted primarily by the lead recovery biologist for the purple bean, summarizes and evaluates new information relevant to the listing status of the species. All pertinent literature and documents on file at the Southwestern Virginia Field Office were used for this review.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review: Initiation of 5-year reviews of nine species: purple bean, clubshell, Roanoke logperch, swamp pink, northern riffleshell, flat-spired three-toothed land snail, puritan tiger beetle, dwarf wedgemussel, and bog turtle. 76 FR 33334-33336; June 8, 2011.

1.3.2 Listing history
FR notice: 62 FR 1647-1658
Date listed: January 10, 1997
Entity listed: species
Classification: endangered

1.3.3 Associated rulemakings
<u>Designation of Critical Habitat</u>
Title: Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Five Endangered Mussels in the Tennessee and Cumberland River Basins; Final Rule
FR notice: 69 FR 53136-53180
Effective date: September 30, 2004

1.3.4 Review History
<u>Previous 5-Year Review</u>

Initiated: 71 FR 20717-20718
Date Finalized: October 24, 2006
Results: No change in status

1.3.5 Species Recovery Priority Number at start of 5-year review (48 FR 43098)
The purple bean is taxonomically categorized as a species, has a high degree of threat, and low recovery potential. Therefore an RPN of 5 has been assigned to the species.

1.3.6 Recovery Plan
Name of plan: Recovery Plan for Cumberland Elktoe (*Alasmidonta atropurpurea*), Oyster Mussel (*Epioblasma capsaeformis*), Cumberland Combshell (*Epioblasma brevidens*), Purple Bean (*Villosa perpurpurea*), and Rough Rabbitsfoot (*Quadrula cylindrica strigillata*) (69 FR Vol. 69, 29569-29570).
Date issued: May 4, 2004

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy: The purple bean is an invertebrate; therefore, it is not covered by the DPS policy.

2.2 Recovery Criteria

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

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat? Yes.

2.2.2.2 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.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information.
Small population size, destruction of habitat, and poor water quality are the predominant factors currently inhibiting the recovery of the purple bean. Therefore, the following downlisting and delisting criteria primarily address listing factor #1 (Present or threatened destruction, modification or curtailment of its habitat or range).

Downlisting from endangered to threatened status will occur when the following criteria are met for the protection of extant stream populations, discovery of currently unknown stream populations, and/or reestablishment of historical stream populations [*Delisting criteria, where different, are italicized and in brackets*]:

(1) Four [*five*] streams with distinct viable populations of the purple bean have been established.

This criterion has not been met. The status of all populations of the purple bean is presently tenuous. In particular, recent surveys of Beech Creek indicated decreasing numbers of purple bean over the last 10 years (Ahlstedt 2011a). Similarly, numbers and recruitment of purple bean have significantly decreased over the last 25 years in Copper Creek (Fraley and Ahlstedt 2000, Hanlon et al. 2009). Agricultural practices related mainly to livestock grazing are suspected to be the dominant negative effect associated with these declines. The status of the Indian Creek population is uncertain; however, this small population is facing increased threats from activities associated with coal mining and natural gas exploration. The largest aggregation of the purple bean in the mainstem Clinch River was extirpated by a chemical spill in 1998. Although individuals of the purple bean still occur throughout the mainstem Clinch River, they are sparsely distributed. Purple bean in the Obed River continues to occur in very low numbers (Ahlstedt et al. 2001). The population in the lower Emory is thought to be nearly extirpated (Ahlstedt et al. 2001). However, numerous individuals were recently reported in upper reaches of the Emory River, extending the range of the purple bean (Ahlstedt 2011b). Although the Emory River population appears to be substantial, habitat is limited and the species is restricted to a relatively short reach of the river.

(2) One [*two*] distinct naturally reproduced year class exists within each of the viable populations.

With the exception of the newly discovered upper Emory River population, the remaining purple bean populations persist with low numbers of individuals and low densities. Even within population centers, the specimens can be very difficult to find. Given the low densities and the rarity of the species, there has been little evidence to demonstrate the existence of distinct naturally reproducing year classes, as young and juvenile specimens are extremely difficult to find. Fraley (2001) reported recruitment had occurred in Beech Creek in 2001. In 2004, a juvenile purple bean was observed in Indian Creek (Jones 2006). There are no other data indicating distinct year classes have naturally reproduced. The level of reproduction has not yet been assessed for the newly discovered upper Emory River population; however, preliminary data indicates the population is substantial and is likely reproducing at a level that has encouraged successful recruitment.

(3) Research studies of the mussel's biological and ecological requirements have been completed and any required recovery measures developed and implemented from these studies are beginning to be successful, as evidenced by an increase in population density of approximately 20 percent and/or an increase in the length of the river reach of approximately 10 percent inhabited by the species as determined through biennial monitoring.

Since its listing in 1997, there have been no data to suggest an increase in density or distribution in any of the remaining populations. Current data suggest populations are continuing to decline. However, life history research on the purple bean (Watson and Neves 1996, Watson 1999) has led to captive propagation success and augmentation efforts for the species (see attachment). Past augmentation efforts have relied on the release of newly metamorphosed juveniles or juveniles that were a few weeks old. To date, there has been no measurable evidence to verify the success of these augmentation efforts. More recently, mussel propagation and culture specialists have improved captive rearing capabilities and are now able to grow purple bean to "sub-adult" size (10-25 millimeters [mm]). Accordingly, managers have now shifted to a strategy of releasing animals once they have achieved "sub-adult" size. This strategy presumably increases survivorship of released animals and enables specimens to be tagged and tracked for post-release monitoring purposes. On October 7, 2010, five propagated sub-adult individuals were released to Indian creek and after 5 months, one specimen was found alive and gravid. This provides some evidence that specimens released as sub-adults persist, develop, and become reproductively mature in the wild. On October 7, 2011, 110 sub-adult (6-month old, shell length13-21 mm) purple bean were released to Indian Creek, potentially doubling the estimated Indian Creek population (Duncan 2011b). Given the level of imperilment of the purple bean and the relative level of benefit to the recovery of the species, this single release may be the most significant of any conducted to date. Future monitoring will determine the effectiveness of these efforts within the context of meeting this recovery criterion.

Although the above examples demonstrate recovery measures developed and implemented to bolster populations, there is no definitive information to assess the success of these efforts to increase population size and distribution. Therefore, this recovery criterion is unmet.

(4) <u>No foreseeable threats exist that would likely impact the survival of the species over a significant portion of its range. [*no foreseeable threats exist that would likely threaten the survival of any of the viable populations*.]</u>

Increasing threats from agriculture, mainly livestock grazing, development, accidental chemical spills, and coal mining and natural gas activities continue to threaten the survival of viable populations; therefore, this recovery criterion is unmet.

(5) <u>Within larger streams, the species are distributed over a long enough reach that a single catastrophic event is not likely to eliminate or significantly reduce the entire population in that stream to a status of nonviable</u>.

Current population distribution and densities of all extant populations of the purple bean do not ensure the continued viability of the population in a stream following a single catastrophic event. For example, in 1998, a chemical spill eliminated the mussel fauna from a 6-mile reach of the upper Clinch River and resulted in the extermination of over 7,000 mussels of 16 species, including 51 purple bean (Jones et al. 2001).

(6) <u>Biennial monitoring yields the results outlined in criterion (1) above over a 10-year period</u>.

This criterion has not been met.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history: Since suitable host fish were determined for the purple bean (Watson and Neves 1996), many attempts have been made to propagate the species to augment extant populations, particularly the Upper Clinch River and Indian Creek population (see attachment). With earlier attempts, managers focused on releasing high numbers of newly metamorphosed juveniles to augmentation sites. This strategy was less expensive than current labor and technology intensive methods to culture the animals to a larger size, and was thought to give the new juvenile mussels the greatest advantage of acclimating to natural conditions. It also seemed like the only option, given failures to successfully keep juvenile purple bean alive under captive conditions for any extended length of time.

The strategy of releasing infested fish directly into augmentation sites takes advantage of the natural dispersal capabilities of host fish and maximizes the natural encystment and exposure to natal conditions. However, follow up monitoring on these efforts has been unable to determine success, particularly when newly metamorphosed juveniles cannot be effectively tagged and distinguished from naturally recruited individuals. Additionally, there is no containment of released infested fish and, therefore, no control over where and when juveniles excyst from hosts and continue life in the stream bottom.

Recent improvements in propagation and culture technologies have enabled facilities to produce and maintain juvenile mussels under captive conditions for longer periods of time, resulting in the production of individuals large enough to affix a small tag to the shell. Given these new capabilities, managers have shifted their focus toward culturing purple bean to a size large enough that animals can be tagged. In 2010, passive integrated transponder tags were affixed to five 3-year-old purple bean that were subsequently released into Indian Creek. Follow up monitoring 5 months later resulted in the recovery of a specimen that was confirmed gravid (Dan 2011). This presents a significant milestone as the first documented success of a purple bean augmentation effort and also serves to demonstrate the capability to fully monitor such efforts.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends: Little information is available regarding species abundance and densities of the various populations. No population viability analyses have been conducted for this species. Several surveys have attempted to quantify abundance in specific reaches of Copper Creek (Ahlstedt 1981, Barr et al. 1993-1994, Hanlon et al. 2009) and Indian Creek (Watson and Neves 1998, Jones and Neves 2004), but there has been no attempt to quantify numbers for the population rangewide.

Upper Clinch River and Indian Creek (Virginia): Although the earliest records by Ortmann (1918) reported the species as "not rare" in the Clinch River, the species has since been found in low numbers within the mainstem Clinch River (Neves 1991, Ahlstedt and Tuberville 1997). The largest population in the Clinch River may have occurred in the upper portion of the river and Indian Creek (Service 2004), prior to a Clinch River chemical spill in late 1998 that resulted in the death of at least 52 specimens (Jones et al. 2001). Watson and Neves (1998) found 26 live purple bean in Indian Creek in 1996-97, which represented 2% of the creek's entire mussel fauna. They provided a conservative estimated of the Indian Creek population of purple bean to be 70 individuals (95% C.I. = 25 to 465 individuals) with an approximate density of 0.002/square meter (m^2). Using 0.25 m^2 quadrat sampling, Jones and Neves (2004) provided a more recent density estimate of 0.047/m^2 within a 1,100 m reach of the lower section of Indian Creek. They estimated the population to be 465 individuals occurring in the lower reach of Indian Creek, coincidently the same number that Watson and Neves (1998) reported as their upper confidence level. The population is likely recruiting at some level, as evidenced by the presence of a young individual estimated to be 1 year old and 22 mm in length (Jones 2006). However, an estimated 10-42% of the Upper Clinch River and Indian Creek population has been extirpated as a result of the 1998 chemical spill, a significant loss that clearly hinders the species recovery. Attempts to reestablish the species within the affected reach of the Clinch River have shown minimal success. A 2007 survey conducted in the Clinch River portion of the population documented one live purple bean that presumably originated from translocation efforts conducted in 2005 (Eckert and Pinder 2009). For these reasons, it is unlikely full restoration of the Upper Clinch River and Indian Creek population has been achieved.

Copper Creek (Virginia): During a 1980 comprehensive survey of Copper Creek, Ahlstedt (1981) documented 77 living specimens of purple bean from 13 sampling sites. Based on that survey, a quantitative sampling effort was subsequently conducted in 1981 at the most productive site (Copper Creek mile 1.9), resulting in an estimated aggregation of purple bean of 1,815.40 individuals (based on 58 quadrat m^2 samples) over a 650-foot reach (approximately 200 m) (Barr 1993-1994). This survey constitutes the highest quantitative estimate of the species and occurred at a time when purple bean represented the dominant species at that location. Neves (1991) considered the Copper Creek population to be the largest in the Clinch River system, but according to more recent survey results, that population has declined substantially in recent years. Fraley and Ahlstedt (2000) found two live specimens and a single fresh dead shell during their 1998 qualitative survey of 20 sites in Copper Creek. Hanlon et al. (2009) conducted a comprehensive survey of Copper Creek and reported 16 live specimens with 66 person hours of effort (catch per unit effort [CPUE] = 0.24/hour [hr]) in the lower

15 mile reach of the creek where purple bean are known to occur. Although more encouraging than findings of Fraley and Ahlstedt (2000), the Hanlon et al. (2009) survey confirms a significant decline from what was reported from the Ahlstedt (1981) survey. In an attempt to obtain quantitative data to compare with Barr (1993-1994), quadrat sampling was conducted at Copper Creek mile 1.9 in 2005 (Hanlon et al. 2009). Out of 51 quadrats (0.25 m^2) sampled, no purple bean were detected. However, two live specimens were documented at this site during the timed search survey in 2004 (Hanlon et al. 2009).

Beech Creek (Tennessee): Discovered in 1980, the only known extant purple bean population in the Holston River system is in Beech Creek, Tennessee. When the population was discovered, it was represented by a large number of purple bean, estimated in the hundreds at one location (Ahlstedt 2011a). In a 2001 survey of 16 sites along mainstem Beech Creek, 74 live purple bean were reported with 33 person hours of effort, resulting in a CPUE of 2.25 purple bean/hr (Fraley 2001). Evidence of recent recruitment was also observed. Coincident with increased riparian development and agricultural impacts in the watershed, the population's viability was thought to be tenuous as numbers of purple bean have declined at a frequented collection site (Service 2004). In February 2001, Fraley (2001) documented 28 live individuals at a CPUE of 9.3 purple bean/hr. Subsequent collection efforts at this site yielded 11 individuals (CPUE 1.83 purple bean/hr) and 5 individuals (CPUE 0.43 purple bean/hr) in February of 2002 and March of 2006, respectively (Virginia Cooperative Fish and Wildlife Research Unit 2002, 2006). However, results of a recent survey conducted in 2012 indicate the population elsewhere in Beech Creek is comparatively robust to results of the 2001survey and is widespread and recruiting (Ostby and Hanlon 2012). Among 29 sites surveyed, a total of 135 living specimens were observed at varying age classes including young juveniles. Catch per unit effort was 1.71 purple bean/hr. Purple bean were not reported in the North Fork of Beech Creek in 2001 despite expended survey effort; however, substantial numbers were documented in the tributary during the 2012 survey.

Emory River (Tennessee): Early occurrence records of purple bean in the Emory River are limited to two collections made in the lower portion of the river around the turn of the 19th century (Pilsbry and Rhoads 1896, Ortmann 1918). Until recently, the status of the Emory River system population was thought to be nearly extirpated. In the most recent survey of the lower Emory River, Ahlstedt et al. (2001) failed to detect the purple bean at all 4 sites that were sampled (14 survey hours). However, a significant population was recently discovered in the upper Emory River near the town of Gobey, Tennessee, about 10 river miles upstream of its confluence with the Obed River (Ahlstedt 2011b). Apparently, the upper Emory River was never surveyed because of its remoteness and inaccessibility (Ahlstedt et al. 2001). In addition, it was believed the limited shoal habitat that occurred in the upper Emory River was impacted by historical logging and fossil fuel exploration for coal, oil, and gas (Faust 2011). No formal survey has been conducted to quantify or determine the extent of the population;

however, several cursory surveys have determined the population center to occur between Emory River mile 37 and 39. The upper Emory River population center may prove to be the most substantial rangewide. Ahlstedt (2011a) documented purple bean as the dominant species with 17 living specimens found with 3 person-hours of search effort.

Obed River (Tennessee): Purple bean were first documented from the river in 1968 by Herbert Athearn (Ahlstedt et al. 2001). Although the specimens were identified as the Cumberland bean (*Villosa trabalis*) at the time, the specimens were most likely purple bean (Ahlstedt et al. 2001). Assessing abundance and population trends of purple bean in the Obed River is difficult because most of the limited pre-2001 survey data for the river is qualitative. According to Ahlstedt et al. (2001), 19 specimens of purple bean were found among 5 of 8 sites surveyed (64.5 sampling hours) in the Obed River. The distribution of purple bean in the Obed River is patchy, with primary aggregations occurring within the middle reaches upstream and downstream of Potter's Ford bridge. Although rare, purple bean were found in the lower reaches near the river's confluence with the Emory River. No subsequent surveys of the Obed River have been conducted since 2001. In the Obed River, the purple bean is considered rare and its viability is questionable (Service 2004).

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.): The species' recovery plan (Service 2004) describes in detail the threat of population fragmentation and genetic considerations. Genomic heterogeneity is lost when the natural interchange of genetic material between populations is prohibited, as in the case with purple bean populations that have been disconnected from each other due to impounded waterways. Because purple bean populations are now restricted and fragmented, they are subject to loss of genomic heterogeneity and more vulnerable to inbreeding depression. Inbreeding depression could ultimately lead to decreased fitness of multiple life stages, and the loss of genetic heterozygosity results in a significantly increased risk of extinction in localized natural populations of the purple bean.

This has particularly important implication for purple bean given its small, relatively isolated populations, because extinction risk increases dramatically with decreasing heterozygosity in the smallest populations (Allendorf and Luikart 2007). It is possible that declines in some of the purple bean populations are attributable to a shortfall in effective population size (i.e., the number of individuals required to maintain long-term genetic viability). The present fragmented distribution and imperiled status of the purple bean may result in a detrimental bottleneck effect, whereby effective population size is not attained. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, potentially increasing susceptibility to inbreeding depression and decreasing the ability to adapt to environmental changes (Allendorf and Luikart 2007).

There has been some speculation that purple bean and the Cumberland bean (*Villosa trabalis*) are variants of the same species or that the purple bean is a subspecies of the Cumberland bean (Parmalee and Bogan 1998). However, no genetic analysis has been conducted to confirm or reject this speculation. By shell character, the two species are indistinguishable, except for the coloration of the nacre. The purple bean has purple nacre that may grade out to almost white; Cumberland bean nacre has color variations of white, bluish white or bluish iridescence (Parmalee and Bogan 1998). Historically, the Cumberland bean occurred in the upper Cumberland River system in Kentucky and the Tennessee River system from the headwaters in Virginia downstream to Muscle Shoals, Alabama. The species is thought to be extirpated from Alabama and from the headwaters of the Tennessee River in Virginia. Purple bean and Cumberland bean were reported as co-occurring in Beech Creek, Hawkins County, Tennessee, and the Obed River, Cumberland County, Tennessee, which has further supported speculation that they may be the same species (Parmalee and Bogan 1998). Furthermore, the two species share similar life habits. Layzer and Madison (1995) noted that detectability of gravid females was greatest for Cumberland bean during December to February, a similar timeframe for when purple bean are gravid and more detectable. Also sculpin (*Cottus* sp.), greenside darter (*Etheostoma blennioides*), and fantail darter (*Etheostoma flabellare*) are confirmed suitable hosts for both mussel species. For both mussel species, glochidia size is the same. Purple bean glochidia range 190-238 micrometers (µm) in length and 238-270 µm in width (Duncan 2011a). Cumberland bean glochidia range 193-220 µm in length and 255-280 µm in width (Williams et al. 2008)

2.3.1.4 Taxonomic classification or changes in nomenclature: There has been no change in the classification or nomenclature of this species since it was listed.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.): The purple bean is endemic to the upper Tennessee River system upstream of what is now Watts Bar Lake. Primarily a species of the Ridge and Valley Physiographic Province, it also occurs at the eastern edge of the Cumberland Plateau. The entire range of the purple bean occurs in northeastern Tennessee and southwestern Virginia.

The purple bean has undergone significant reductions in total range and population density. The species has been extirpated from the Powell River, North Fork Holston River, and Daddys Creek. Having once existed in hundreds of river miles, the species now survives in a few, generally small, isolated populations, most of which exhibit questionable long-term viability. Opportunities for recolonization of extirpated rivers and streams and genetic exchange among populations has been essentially eliminated as a result of numerous impoundments and reservoirs constructed throughout the Tennessee River system. The remaining population centers reside in tributaries or headwaters streams of the Clinch, Holston, and Emory Rivers. Five streams have been identified as supporting the primary populations, Indian Creek, Tazewell County, Virginia; Copper Creek, Scott County, Virginia; Obed River, Cumberland County, Tennessee; Emory River, Morgan County, Tennessee; and Beech Creek, Hawkins County, Tennessee.

Individuals are occasionally found in the mainstem of the Clinch River, Tazewell, Russell, and Scott Counties, Virginia; however, the population is sparse, and there are no quantifiable data to evaluate it as a population aggregation. Although, this does suggest some limited level of connectivity between the Copper Creek and Indian Creek populations, this connectivity is likely not strong enough to support any effective genetic interaction. For example, if one stream population were to become extirpated from a chemical spill or stochastic event, connectivity with the other populations would not be adequate for recolonization.

As described in section 2.3.1.2 above, the purple bean was recently discovered in the upper Emory River, a river reach that had not been formerly investigated. Although the population in the lower Emory River is declining, the upper Emory River represents an expansion in the species range and may be among the most viable of the remaining populations.

2.3.1.6 Habitat or ecosystem conditions: The purple bean, generally adapted to gravel shoals of free-flowing streams, is restricted to tributary streams of the upper reaches of the Tennessee River system. Ideal habitat conditions are difficult to find. Much of the historical habitat for the species has been degraded, and may currently be unsuitable for occupation by the species or enabling adequate recruitment. The habitat is currently being negatively impacted by excessive sediment bed loads of smaller sediment particles, changes in turbidity, increased suspended solids (primarily resulting from nonpoint source loading and lack of, or maintenance of, best management practices [BMPs]), and pesticides. Other, primarily localized, habitat impacts result from coal mining, gas development, urban and rural development activities, impoundments, and non-native species.

2.3.2 Five-Factor Analysis

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range: The species' recovery plan provides a detailed and up-to-date analysis of the present or threatened destruction, modification, or curtailment of the species' habitat and range. No new or additional information is available.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes: The species' recovery plan summarizes the history of the exploitation of North American freshwater mussels primarily by Native

Americans, the pearl button industry, and the relatively recent cultured pearl industry. However, it is doubtful purple bean have ever been exploited for such activities.

Although current scientific collecting is not thought to represent a significant threat, localized populations of the purple bean could be impacted and possibly extirpated by over-collecting, particularly if this activity is unregulated. Specimens of purple bean have been collected for museums or to provide broodstock for laboratory propagation. Past attempts to establish an ark population proved ineffective because of increased incidences of mortality, presumably caused by stressors related captive conditions (Duncan 2010). Due to the apparent sensitivity of this species to captive holding, permitted propagation programs now limit the number of purple bean used for propagation efforts and minimize the duration of holding specimens. The number of individuals held in propagation facilities, both now and in the past, is not considered to be excessive.

On the basis of the best scientific and commercial data available, we find that overutilization for commercial, recreational, scientific, or educational purposes is currently not a threat to the purple bean in any portion of its range or likely to become a significant threat in the foreseeable future.

2.3.2.3 Disease or predation: The species' recovery plan provides a detailed and up-to-date analysis of disease and predation. As indicated in the recovery plan, muskrat predation on rare mussels has been shown to be potentially detrimental to their recovery (Neves and Odom 1989). We believe it continues to be a problem in localized stream reaches in at least the upper Tennessee River system. Specifically, the Indian Creek population of the purple bean has been affected by muskrat and possibly raccoon predation. A predator control program has been implemented over the past decade to control this threat. Monitoring seems to indicate that predation has been minimized.

2.3.2.4 Inadequacy of existing regulatory mechanisms: According to a 1996 non-jeopardy biological opinion (BO) and conference report issued to the U.S. Office of Surface Mining Reclamation and Enforcement (OSM) regarding surface coal mining and reclamation operations under Surface Mining Control and Reclamation Act (SMCRA), Species Specific Protective Measures (SSPMs) were to be developed with the objective of minimizing potential take of federally listed species during lawful mining activity (Service 1996). Although draft SSPMs were developed in Virginia, they have not been finalized or implemented. Purple bean populations in Indian Creek and the mainstem of the Clinch River remain vulnerable to the impacts of coal mining.

Point source discharges within the range of the purple bean have been reduced since the inception of the Clean Water Act (33 U.S.C. 1251 et seq.), but this may not provide adequate protection for filter-feeding organisms that can be impacted by extremely low levels of contaminants. There is no specific information on the sensitivity of the purple bean to common industrial and municipal pollutants and little information on other freshwater mussels. Freshwater mussels are sensitive to a variety of water contaminants, especially during early life stages.

Toxicological studies on freshwater mussels have demonstrated that current Environmental Protection Agency (EPA) water quality criteria for ammonia and copper are not protective of all life stages of many freshwater mussel species (Augspurger et al. 2003; Wang et al. 2007a, b). Although not finalized, the EPA is currently considering inclusion of freshwater mussels in the toxicity database that is used to set water quality criteria for primary pollutants (such as chlorine and copper) and non-priority pollutants (such as ammonia). A lack of adequate research and data may prevent existing regulations, such as the Clean Water Act, from being fully and effectively utilized.

Section 7 of the Endangered Species Act (ESA) requires Federal agencies to consult with the Service when actions they fund, authorize, or carry out may affect purple bean. However, there is no Federal regulation of many actions likely impacting purple bean habitat. Because some of the threats involve activities that do not have a Federal nexus (such as water quality changes resulting from development, water withdrawals, or indiscriminate logging), they may require section 10 permits under the ESA. Frequently the Service is not informed/aware these types of activities are being considered, planned, or implemented; therefore, there is no opportunity to provide input into project design or to inform project proponents of the need for a section 10 permit. Although take prohibitions of section 9 of the ESA apply to these activities, enforcement is difficult.

Sources of nonpoint source pollution include timber clearcutting, clearing of riparian vegetation, urbanization, road construction, and other practices that allow eroded earth to enter streams. Current laws do not adequately protect purple bean habitat from nonpoint source pollution, as the laws to prevent sediment entering waterways are poorly enforced. BMPs for sediment and erosion control are often recommended or required by local ordinances for construction projects; however, compliance, monitoring, and enforcement of these recommendations are often poorly implemented. Despite the introduction of BMP cost share programs, there is a lack of evidence suggesting that agricultural perturbations are being curtailed significantly. Conversion of bottomland and riparian forest to pasture may be pivotal in the decline of purple bean populations, particularly in Copper Creek. Currently, there are no regulatory mechanisms to maintain stream buffers to adequately protect stream habitat from livestock access and loss of functional riparian vegetation.

In addition to the federal listing, the purple bean is listed as Endangered by the State of Tennessee. Under the Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 (Tennessee Code Annotated §§ 70-8-101-112), "…it is unlawful for any person to take, attempt to take, possess, transport, export, process, sell or offer for sale or ship nongame wildlife, or for any common or contract carrier knowingly to transport or receive for shipment nongame wildlife." Further, regulations included in the Tennessee Wildlife Resources Commission Proclamation 00-15 Endangered Or Threatened Species state the following: except as provided for in Tennessee Code Annotated, Section 70-8-106 (d) and (e), it shall be unlawful for any person to take, harass, or destroy wildlife listed as threatened or endangered or otherwise to violate terms of Section 70-8-105 (c) or to destroy knowingly the habitat of such species without due consideration of alternatives for the welfare of the species listed in (1) of this proclamation, or (2) the United States list of Endangered fauna. Similarly, the purple bean is listed as an endangered species under Virginia state wildlife law (Virginia Code Annotated §§ 29.1-563-570) prohibiting the taking, transportation, possession, sale, or offer for sale within the Commonwealth. Violation of this provision can result in a Class 1 misdemeanor. Both states require state collection permits for potential collectors of this species.

2.3.2.5 Other natural or manmade factors affecting its continued existence: The species' recovery plan summarizes population fragmentation and genetic considerations related to patterns of imperilment. The limited geographic range and apparent small population size of the species leaves it 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 purple bean 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 purple bean whose historic 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).

2.4 Synthesis

The purple bean is endemic to the upper Tennessee River system above Watts Bar Lake and the entire range of the species is restricted to northeastern Tennessee and southwestern Virginia. The purple bean is currently restricted to tributary streams of the upper reaches of the Tennessee River system where much of its historical habitat has been degraded and currently may be unsuitable for occupation and/or adequate recruitment.

This species has been extirpated from the Powell River, North Fork Holston River, and Daddys Creek. Although tenuous, extant populations occur in isolated portions of the Clinch River, Tazewell, Russell, and Scott Counties, Virginia; Indian Creek, Tazewell County, Virginia; Copper Creek, Scott County, Virginia; and Obed River, Cumberland County, Tennessee. Previously thought declining, the population in Beech Creek, Hawkins County, Tennessee is relatively robust and recruiting. It was previously thought to be extirpated from North Fork Beech Creek, however, 2012 survey results prove the population to be reestablished and as an extension of a recruiting population in the mainstem of Beech Creek. Once thought nearly extirpated from the Emory River, a significant population was recently discovered in the upper Emory River, Morgan County, Tennessee; however, the demographics and extent of the population have not been fully determined.

Muskrat, and possibly raccoon, predation continues to be a threat in localized stream reaches in at least the upper Tennessee River system. A predator control program has been implemented, and monitoring seems to indicate that predation has been minimized. The purple bean and its habitat continue to be negatively impacted by excessive sediment bed loads and increased suspended solids, primarily resulting from nonpoint source loading from poor land-use practices, riparian degradation, and pesticides. Activities associated with coal and gas exploration pose a threat to the recovery of the Indian Creek and mainstem Clinch River populations. Toxic spills and nonnative species are possible threats to all extant populations. Despite an improved understanding of these consequences leading to regulatory actions, voluntary BMPs on private and public lands, and improved land-use practices (e.g., maintaining riparian buffers and livestock exclusion), measurable improvements in habitat condition for the purple bean have not been realized. With the exception of the recently discovered upper Emory River population, extant purple bean populations show no sign of recovery from historical habitat losses and continual chronic nonpoint source impacts. The limited geographic range and apparent small population size of the species leaves it extremely vulnerable to localized extirpations from stochastic disturbances and decreased fitness from reduced genetic diversity.

Given its highly restricted distribution, the vulnerability of remaining populations, and its currently declining status, the purple bean continues to meet the definition of endangered.

3.0 RESULTS

3.1 Recommended Classification

__X_ No change is needed

3.2 New Recovery Priority Number: No change is needed

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

<u>Population and habitat actions</u>

- Continue improving propagation and culture technologies and efforts, and monitor fate of released individuals (addresses recovery action 4.1).
- Continue to use existing legislation and regulations to protect the species and its habitat (addresses recovery action 1.1).
- Pursue and establish protective criteria for known and suspected pollutants (addresses recovery action 1.1).

- Through various means of land protection (land acquisition, BMP programs, conservation easements), abate nonpoint source impacts and direct habitat loss (addresses recovery action 1.3.3).
- Educate the public about impacts to habitat and water quality (addresses recovery action 7.1).
- Foster support for recovery through partnerships and landowner participation (addresses recovery action 1.3.3).

Research and Information Needs (in order of priority)

1. Determine extent and demographics of upper Emory River population (addresses recovery action 3).
2. Conduct land cover analysis to determine thresholds for species decline and recovery and establish realistic benchmarks for restoration, particularly for Copper Creek and Beech Creek populations (addresses recovery action 6).
3. Conduct genetic analysis to determine the taxonomic relationship between *Villosa perpurpurea* and *Villosa trabalis* (addresses recovery action 1.4.7).

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U.S. FISH AND WILDLIFE SERVICE
5-Year Review of purple bean (*Villosa perpurpurea*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable:

Review Conducted By: Shane Hanlon, Southwestern Virginia Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Cynthia A Schulz Date 11-1-13

for
Cooperating Regional Director, Fish and Wildlife Service

_✓_ Concur _____ Do Not Concur

Signature Aaron L Valenta Date 10-30-13

Attachment: Purple bean augmentation summary.

Numbers of purple bean (*Villosa perpurpurea*) produced via captive propagation and released to various sites within the Upper Tennessee River Basin (Hanlon 2011, unpub. data). Note that mussels released as glochidia on infested fish (IF) are not aged until metamorphosis occurs.

Release Site	Year of Release	Age of Mussel at Release	Number of Mussels Released (*estimated)
Clinch R., Hancock Co., TN	1999	1 wk	138
Indian Creek., Tazewell Co., VA	1999	1-2 wks	1,822
Indian Creek., Tazewell Co., VA	2000	1-2 wks	3,088
Indian Creek., Tazewell Co., VA	2001	2 wks	124
North Fork Holston R., Hawkins Co., TN	2002	4 wks	1,123
Clinch River, Tazewell Co., VA	2002	2 wks	10,573
Clinch River, Hancock Co., TN	2002	3 wks	616
Clinch River, Tazewell Co., VA	2003	2 wks	5,500
Clinch River, Tazewell Co., VA	2004	8 wks	121
Clinch River, Tazewell Co., VA	2004	6 mo	66
Clinch River, Tazewell Co., VA	2004	IF	*1,800
Clinch River, Tazewell Co., VA	2004	6 wks	302
Copper Creek, Scott Co., VA	2004	3 wks	16
Indian Creek, Tazewell Co., VA	2005	1-2 wks	1,044
Copper Creek, Scott Co., VA	2005	1 wk	83
Clinch River, Tazewell Co., VA	2005	3 wks	455
Indian Creek, Tazewell Co., VA	2005	4 wks	400
Copper Creek, Scott Co., VA	2006	3 wks	389
Indian Creek, Tazewell Co., VA	2007	1-2 wks	1,624
Indian Creek, Tazewell Co., VA	2007	18 mo	4
Indian Creek, Tazewell Co., VA	2007	8 wks	428
Indian Creek, Tazewell Co., VA	2008	2 wks	945
Indian Creek, Tazewell Co., VA	2008	IF	*500
Indian Creek, Tazewell Co., VA	2009	IF	*1,500
Indian Creek, Tazewell Co., VA	2010	16 mo	5
Indian Creek, Tazewell Co., VA	2010	41 mo	5
Indian Creek, Tazewell Co., VA	2011	6 mo	110
Copper Creek, Scott Co., VA	2011	19	7
TOTAL			**32,788**