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# FRESHWATER MUSSELS OF THE NATIONAL PARK SERVICE OBED WILD AND SCENIC RIVER, TENNESSEE

Steven A. Ahlstedt[1], Joseph F. Connell[2], Steve Bakaletz[3], and Mark T. Fagg[4]

## ABSTRACT

The Obed River was designated as a Wild and Scenic River (WSR) in 1976 and is a unit of the National Park Service. The river is considered to be among the highest quality in the state of Tennessee supporting a rich ecological diversity. Two federally listed species (one fish and one mussel) occur in the Obed: spotfin chub *Cyprinella monacha*, and purple bean *Villosa perpurpurea*. The Obed is a major tributary to the upper Emory River. Historical mussel collections and recent sampling have documented 27 species in the drainage. Freshwater mussel sampling was relegated to the Obed WSR and tributaries to determine species composition, abundance, and whether reproduction and recruitment is occurring to the fauna. Mussel sampling was conducted from 2000-2001 within the boundaries of the WSR at access points throughout the length of the Obed including portions of the upper Emory River, Daddy's, Clear, and Whites creek. A total of 585 mussels representing nine species were found during the study. The most abundant mussel found was *Villosa iris* that comprised 55% of the fauna, followed by *Lampsilis fasciola* 19% and *Medionidus conradicus* 14%. The federally endangered *V. perpurpurea* was represented at 3%. Two species, *Pleuronaia barnesiana* (live) and *Lampsilis cardium* (fresh dead), were found as single individuals and *P. barnesiana* is a new distribution record for the Obed. The mussel fauna in the Obed WSR is relatively rare and historically the river may never have had a more diverse fauna because of the biologically non-productive nature of shale and sandstone that characterize streams on the Cumberland Plateau. Mostly larger size-class mussels measured suggests older adult individuals with minimum or no recruitment of some species to the fauna. Mussel reproduction and recruitment may be exacerbated from human activities outside the boundaries of the WSR, which influence the quality of water within its boundaries.

Key words: Tennessee, Emory River, Obed River, Cumberland Plateau, Unionidae, endangered species.

## INTRODUCTION

The Obed Wild and Scenic River (WSR) was created in 1976 as an amendment to the Wild and Scenic Rivers Act of 1968 (Public Law 90-542) and is a unit of the National Park Service (NPS). The NPS has primary management responsibilities for the unit's resources, uses, and facilities. As of 1996, the Obed is one of 158 wild and scenic rivers nationally and is one of nine river systems authorized in the southeastern United States. It is the only national wild and scenic river in the state of Tennessee and lands within the WSR are shared with the Tennessee Wildlife Resources Agency (TWRA). The TWRA is responsible for those parts of the river under a Memorandum of Understanding (#MU5130-4-8002) for cooperative management of Catoosa Wildlife Management Area lands within the legislated Obed WSR boundaries (shared lands) (NPS, 1994).

Water resources and riparian environments are the principal resources of the Obed WSR. The water is considered to be among the highest quality in the state supporting a rich ecological

[1]P. O. Box 460, Norris, Tennessee 37828 U.S.A.
[2]108 Orchard Circle, Oak Ridge, Tennessee 37830 U.S.A.
[3]United States National Park Service, 4564 Leatherwood Ford Rd., Oneida, Tennessee 37841 U.S.A.
[4]Tennessee Wildlife Resources Agency, 3030 Wildlife Way, Morristown, Tennessee 37814 U.S.A.

diversity (NPS, 1994). Human activities outside the boundaries of the WSR influence the quality of water within its boundaries. This includes: coal mining, oil and gas exploration, quarrying, sewage discharge, agriculture and forestry practices, residential development, garbage disposal, and the construction of numerous water supply ponds and impoundments. Major population centers and retirement communities surround the Obed WSR, further threatening water quality and quantity in the drainage. During the early 1990s, human population growth was 13% and is expected to continue to grown at same rate in the future, Tennessee Valley Authority (TVA, 1998).

Water availability to the river and the Cumberland Plateau in general is especially crucial because of the geologic nature of underlying Pennsylvanian sandstone, conglomerate, shale, and coal that forms an impermeable cap-rock (Nashville Dome) over underlying water-soluble Mississippian limestone and dolomite. Most of the sandstone and conglomerate have low intergranular porosity that is impervious to rainfall and provides little ground-water storage (Gaydos 1982). Streams of this nature are relatively clear and not as biologically productive as streams in the Ridge and Valley Physiographic province that consists almost entirely of Mississippian limestone and dolomites. High gradient streams like the Obed on the Cumberland Plateau have little groundwater storage capacity. This causes rapid surface runoff during periods of high rainfall. During periods of low rainfall, flows are reduced and many smaller tributaries are dry (TVA, 1968). These flow patterns are typically what we see today in Cumberland Plateau streams. However, this boom or bust cycle of water availability may have naturally been maintained at a much higher flow levels for millennia than during the present. Human activities outside the boundaries of the WSR are growing and the demands for consumptive water usage are increasing making less water available to the river system. Recent establishment of hundreds of water supply and recreational use reservoirs near the Obed River and its principal tributaries and proposals for larger reservoirs in the watershed have the potential to affect future water resources that the NPS is mandated to preserve (TVA, 1998; NPS, 2001).

## PURPOSE AND SCOPE

The U.S. Geological Survey entered into a contract with the National Park Service to provide the most recent information on the mussel resources of the Obed WSR. This report describes an investigation to determine what federally listed and other freshwater mussel species currently exist that the NPS is mandated to protect within the Obed WSR. A combination of qualitative and quantitative sampling techniques was used to determine if mussels were present and their relative abundance. Permanent fixed station sites are recommended so that the NPS can establish baseline data for monitoring the health of mussel populations over time. This establishes trend data on whether the health of mussel populations are improving or declining over time. The presence and/or absence of mussels are excellent surrogate species for determining water quality.

## THREATENED AND ENDANGERED SPECIES

Several state and federally listed endangered, threatened, or rare aquatic species are documented from the Emory River drainage including the Obed WSR. This includes one fish and four mussel species: spotfin chub, *Cyprinella monacha*; turgid blossom, *Epioblasma turgidula* (Lea, 1858); Alabama lampmussel, *Lampsilis virescens* (Lea, 1858); fine-rayed pigtoe,

*Fusconaia cuneolus* (Lea, 1840); and purple bean *Villosa perpurpurea* (Lea, 1861). The U.S. Fish and Wildlife Service (USFWS) prepared recovery plans for the spotfin chub (Boles, 1983), turgid blossom (USFWS, 1985a), fine-rayed pigtoe (USFWS, 1984), Alabama lampmussel (USFWS, 1985b), and a technical/agency draft recovery plan for the purple bean (USFWS, 1998). The recovery plan for the spotfin chub have several of the following stream segments designated as critical habitat: Emory and Obed rivers; Clear and Daddy's creeks in Morgan County; Clear Creek in Fentress County; and Obed River upstream to Tennessee State Highway 127 Bridge crossing in Cumberland County (Boles, 1983). Only two federally listed species, spotfin chub and purple bean, occur in the Obed WSR. The turgid blossom is now considered extinct and the fine-rayed pigtoe is considered extirpated from the Emory River. However, the Alabama lampmussel and the purple bean were only recently re-discovered in 2011 (H. Faust, pers. comm.) in the upper Emory River upstream of its confluence with the Obed.

***Historical Mussel Records (pre-1970)***

Information concerning the historical occurrence of freshwater mussels in the Emory River system is limited to two collections made around the turn of the century by Pilsbry and Rhoads (1896), and Ortmann (1918) on the lower Emory River near Harriman. Six species were reported by Pilsbry and Rhoads, and Ortmann found 15 species (Table 1). This represents the only information that exists on the historical occurrence of mussels in the lower Emory (pre-1970), and no information is known for what occurred historically around the turn of the century in the Obed, or its major tributary streams—Clear and Daddy's creeks. It is unknown what may have occurred farther upstream in the Emory River drainage because of its remoteness and inaccessibility. However, the City of Harriman appears to be a transition zone between the more biologically unproductive sandstone and shale of the Cumberland Plateau and the more biologically productive limestone and dolomite of the Valley and Ridge (D. Etnier, pers. comm.). This would account for the relative high diversity of mussels reported historically in the lower Emory near Harriman and would account in part for the low mussel diversity that occurs today in the Obed.

In 1967 and 1968, H. T. Athearn (Museum of Fluviatile Mollusks, Cleveland, Tennessee, pers. comm.) collected mussels and snails in the Obed River at two sites: near Frankfort and Genesis Road Bridge (both in Morgan County), and one site on Daddy's Creek near Frankfort. He reported six mussel species from both the Obed and Daddy's Creek (Table 2). This is the earliest known mussel sampling record for both streams and following is a list of species and number of specimens found: Obed, *Lampsilis cardium* Rafinesque 1820 (1), *L. fasciola* Rafinesque 1820 (38), *Pleurobema oviforme* (Conrad, 1834) (14), *Villosa iris* (Lea, 1829) (48), *V. vanuxemensis* (Lea, 1838) (2), and *V. trabalis* (Conrad, 1834) (23); Daddy's Creek, *Fusconaia subrotunda* (Lea, 1831) (10), *L. fasciola* (51), *P. oviforme* (28), *V. iris* (14), *V. trabalis* (2), and *V. vanuxemensis* (2). The record for *Villosa trabalis* is questionable since it can be only separated from *V. perpurpurea* based on the nacre color on the inside of the shell. Externally, both species look identical but internally *V. trabalis* has white nacre, and *V. perpurpurea* has purple nacre. Further, *V. trabalis* has never been documented in the Emory River drainage and both species are federally listed endangered. Parmalee and Bogan (1998) in their book "*Freshwater Mussels of Tennessee"* report four species in the Obed including both *V. trabalis* and *V. perpurpurea*. Parmalee (pers. comm.) later determined that only *V. perpurpurea* exists, not *V. trabalis*, in the Obed. This was based on the purple nacre color of specimens curated at the McClung Museum, The University of Tennessee, Knoxville.

Table 1— Freshwater mussels reported from the Emory River, Obed River and Daddy's Creek: Pilsbry and Rhoads **PR** (1896); Ortmann **O** (1918); Starnes and Bogan **SB** (1988); Parmalee and Bogan **PB** (1998); H. T. Athearn **HA** 1967-1968; Stansbery **S** 1974, 1979, 1984, 1988; Robert Anderson **RA** 1988.

| | Emory | | | | Obed | | | Daddy's Cr. |
|---|---|---|---|---|---|---|---|---|
| **Mussel Species** | **PR** | **O** | **SB** | **PB** | **HA** | **S** | **RA** | **HA** |
| *Actinonaias* spp. | - | - | - | - | - | - | ? | - |
| *Amblema plicata* | - | X | X | X | - | - | - | - |
| *Anodonta suborbiculata* | - | - | - | X | - | - | - | - |
| *Elliptio crassidens* | - | X | X | X | - | - | - | - |
| *Elliptio dilatata* | X | X | X | X | - | - | - | - |
| *Epioblasma turgidula** | - | X | X | X | - | - | - | - |
| *Fusconaia barnesiana* | X | - | X | X | - | - | - | - |
| *Fusconaia cuneolus** | X | X | X | X | - | - | - | - |
| *Fusconaia flava* | - | - | - | - | - | - | ? | - |
| *Fusconaia subrotunda* | - | - | - | - | - | - | - | X |
| *Lampsilis cardium* | - | X | X | X | X | - | - | - |
| *Lampsilis fasciola* | - | X | X | X | X | X | X | X |
| *Lampsilis virescens** | - | X | X | X | - | - | - | - |
| *Lasmigona costata* | - | X | X | X | - | - | - | - |
| *Leptodea fragilis* | - | - | X | X | - | - | - | - |
| *Medionidus conradicus* | X | - | X | X | - | - | X | - |
| *Pleurobema oviforme* | - | X | X | X | X | - | - | X |
| *Potamilus alatus* | - | - | X | X | - | - | - | - |
| *Potamilus ohiensis* | - | - | - | X | - | - | - | - |
| *Ptychobranchus fasciolaris* | X | X | X | X | - | - | - | - |
| *Pyganodon grandis* | - | - | - | X | - | - | - | - |
| *Toxolasma lividus* | X | X | X | X | - | - | - | - |
| *Truncilla donaciformis* | - | - | - | X | - | - | - | - |
| *Utterbackia imbecillis* | - | - | - | X | - | - | - | - |
| *Villosa iris* | - | X | X | X | X | X | X | X |
| *Villosa perpurpurea** | - | X | X | X | X | X | X | X |
| *Villosa vanuxemensis* | - | X | X | X | X | - | - | X |
| Total (27) | 6 | 15 | 19 | 24 | 6 | 3 | 4 | 6 |

Federally listed endangered*
Questionable records?

***Recent Mussel Records (post-1970)***

Parmalee and Bogan (1998) added six additional species documented from the Emory River. All six species, *Anodonta suborbiculata* Say 1831*, Leptodea fragilis* Rafinesque 1820*, Potamilus ohiensis* (Rafinesque, 1820), *Pyganodon grandis* (Say, 1829), *Truncilla donaciformis* (Lea, 1828), and *Utterbackia imbecillis* (Say, 1829), are thin-shelled mussels that have successfully colonized post-impoundment of the Tennessee River including the lower Emory River. With the exception of *P. ohiensis* listed above, the remaining five species reported by Parmalee and Bogan (1998) are mussel records from a 1981 TVA survey at a proposed barge terminal on the lower impounded Emory River (S. Ahlstedt, unpublished field records). All totaled, 27 mussel species are documented from the Emory River drainage and excluding the mussels mentioned above, or what currently exists in tributaries, almost all are extirpated from the free-flowing main-stem Emory River (Table 1).

Table 2— Mussel and snail collection records Obed and Daddy's Creek.

Herbert T. Athearn
Museum of Fluviatile Mollusks
Cleveland, Tennessee

Obed River, 7.7 km SW of Genesis, Morgan Co., TN, April 1967
*Lampsilis fasciola* 15
*Villosa iris* 8

Obed River, 4.6 km ESE of Frankfort, Morgan Co., TN, September 1968
*Lampsilis cardium* 1
*Lampsilis fasciola* 30
*Pleurobema oviforme* 14
*Villosa iris* 34
*Villosa trabalis* 23
*Villosa vanuxemensis* 2
*Elimia proxima* (snail) 30

Daddy's Creek, 4.3 km SE of Frankfort, Morgan Co., TN, September 1968
*Fusconaia subrotunda* 10
*Lampsilis fasciola* 51
*Pleurobema oviforme* 28
*Villosa iris* 14
*Villosa trabalis* 2
*Villosa vanuxemensis* 6
*Elimia proxima* (snail) 100

Freshwater mussel records obtained from Dr. David Stansbery, The Ohio State University, Museum of Zoology, at Columbus, Ohio report collections made in the Obed in 1974, 1979, 1984, and 1988. Three mussel species were found in 1974 (*L. fasciola*, *V. iris*, and *V. perpurpurea*) and mussels collected in 1979, 1984, 1988 were preserved and listed as not processed (cataloged) into the museum collections. At present, it's currently unknown what species were collected and preserved; however, the author was present with Stansbery in 1984 during a mussel workshop field-collecting trip to the Obed at Potter's Ford Bridge. Three mussel species were observed live: *L. fasciola, V. iris*, and *V. perpurpurea* (Table 1).

In 1988, Robert Anderson a graduate student at Tennessee Technological University, Cookeville (unpublished field records), and Richard Biggins (USFWS, Endangered Species Field Office, Asheville, North Carolina) floated the Obed in canoes and found four mussel species live at nine sites: *L. fasciola, Medionidus conradicus* (Lea, 1834), *V. iris,* and *V. perpurpurea*. Two additional mussels, *Actionaias* sp. and *Fusconaia flava* (Rafinesque, 1820) could not be positively identified because of the eroded condition of the shell. Both eroded specimens are questionable records because *Actinonaias* sp. has never been documented from the Emory River drainage, and *F. flava* does not occur in eastern Tennessee streams (Parmalee and Bogan, 1998) (Table 1).

Additional mussel records are rare in the Emory, Obed, and Clear Creek. The TVA in the mid-1980s established a permanent fixed station site for monitoring fish, macroinvertebrates, and water quality on the lower Emory River near Deermont. Mussels were sampled in 1995 and a single individual specimen of *L. fasciola* was found. In 1995, TWRA completed mussel surveys on the Emory River at Nemo and Oakdale Bridge crossings that were going to be replaced by the Tennessee Department of Transportation (TDOT). Live specimens of *Potamilus alatus* (Say, 1817) were reported from both bridge sites and relict specimens of *Pleuronaia*

*(=Fusconaia) barnesiana* (Lea, 1838), and *V. iris* were found at Oakdale (D. McKinney, pers. comm.). In 1998, the U.S. Geological Survey, upper Tennessee River National Water Quality Assessment (NAWQA) program sampled fish, macroinvertebrates, algae, and water quality throughout the Emory River drainage (Hampson, 1995; Hampson *et al*., 2000). Mussels were reported from the following locations: lower Emory River at Oakdale, relict specimen of *P. alatus*; Obed River at Potter's Ford Bridge: four live *L. cardium, L. fasciola, Villosa iris*, and *V. perpurpurea*; and Clear Creek at Norris Ford: two live *L. fasciola* and *V. iris*.

## DESCRIPTION OF STUDY AREA

The Obed River is located in north-central Tennessee on the Cumberland Plateau in Cumberland and Morgan counties (Fig. 1). The Plateau lies east of the Highland Rim and Nashville Basin Provinces. Existing boundaries encompass 5,056 acres (2,046 hectares) including 45.2 river miles (72.7 kilometers) of the Emory River, Obed River and two Obed River tributaries - Clear Creek and Daddy's Creek. The headwaters of the Obed originate a few miles northwest of Crossville and is the largest tributary of the Emory River with a total drainage area of 520 square miles. The river flows easterly towards its junction with the Emory River through a deep sandstone gorge characterized by high stream gradient, boulders and bedrock, and interspersed with clear, long, deep pools. A long line of cliffs (escarpment), separate it from the lower elevations of the Ridge and Valley Province to the east (Gaydos, 1982). These characteristics have caused the river corridor to remain relatively uninhabited and inaccessible except for logging and mining camps that were established during the 19th and early 20th centuries (NPS, 1994). The Obed River is considered to be outstanding in the spring for whitewater kayaking because of high surface water flows.

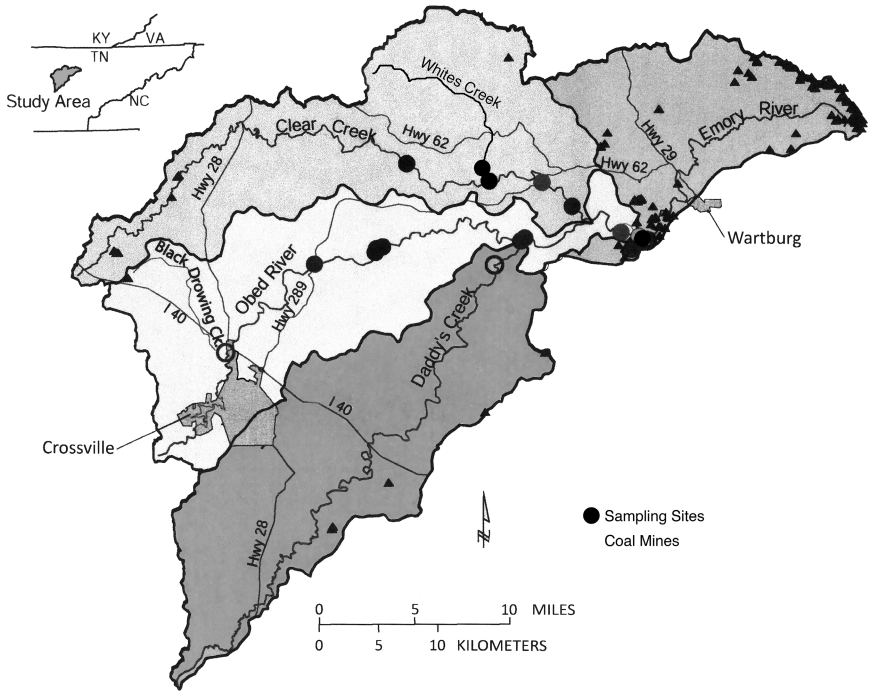


Figure 1— Location of freshwater mussel collection sites, Emory River basins.

Table 3— Location of all freshwater mussel collecting sites within the boundaries of the Obed WSR (Obed River, Daddy's Creek, Clear Creek, Whites Creek, Emory River).

| Site | River Mile | GPS Coordinates | River/Location |
|---|---|---|---|
| | | | Emory River |
| 1 | 27.4 | 36°04'02"N-84°39'41"W | Below Nemo Bridge - Morgan Co., TN |
| 2 | 27.8 | 36°04'10"N-84°39'39.5"W | Above Nemo Bridge - Morgan Co., TN |
| 3 | 28.5 | 36°04'31"N-84°38'59"W | Confluence Obed R. - Morgan Co., TN |
| 4 | 28.7 | 36°04'34"N-84°38'52"W | Upstream from Obed R. - Morgan Co., TN |
| | | | Obed River |
| 5 | 0.4 | 36°04'44.2"N-84°39'13.5"W | Above confluence Emory - Morgan Co., TN |
| 6 | 1.5 | 36°04'56"N-84°40'15"W | Alley Ford - Morgan Co., TN |
| 7 | 9.1 | 36°04'45"N-84°45'46.1"W | Mouth Daddy's Creek - Morgan Co., TN |
| 8 | 20.4 | 36°04'26"N-84°53'50"W | Island Elmore Creek - Cumberland Co., TN |
| 9 | 20.7 | 36°04'21"N-84°54'10"W | Potters Ford Br. - Cumberland Co., TN |
| 10 | 21.1 | 36°04'11.3"N-84°54'15"W | Above Potters Ford Br. - Cumberland Co., TN |
| 11 | 24.9 | 36°03'42"N-84°57'42"W | Adams Bridge - Cumberland Co., TN |
| 12 | 34.5 | 35°59'04"N-84°02'49.2"W | Black Drowning Cr.- Cumberland Co., TN |
| | | | Clear Creek |
| 13 | 1.6 | 36°06'09"N-84°43'03"W | Upstream Lilly Bridge - Morgan Co., TN |
| 14 | 4.5 | 36°07'15"N-84°44'44"W | Upstream Jett Bridge - Morgan Co., TN |
| 15 | 8.7 | 36°07'21"N-84°47'44"W | Upstream Barnett Bridge - Morgan Co., TN |
| 16 | 14.8 | 36°08'11.3"N-84°52'23.7"W | Norris Ford - Morgan/Cumberland Co., TN |
| | | | Whites Creek |
| 17 | 0.4 | 36°07'56.4"N-84°48'03.5"W | Whites Ford - Morgan Co., TN |
| | | | Daddy's Creek |
| 18 | 0.1 | 36°04'37"N-84°46'00"W | 300 yards upstream Obed R.- Morgan Co., TN |
| 19 | 2.4 | 36°03'33"N-84°47'31"W | Devil Breakfast Table - Cumberland Co., TN |

## MATERIALS AND METHODS

Freshwater mussel sampling consisted of snorkeling sites accessible by road or foot trail. Sampling consisted of visual searching, digging, and fanning of substrate looking for mussels that are typically buried or partially exposed. Searches also were done under large flat rocks, boulders, and seams or creases in bedrock. Many of the live mussels found in the Obed WRS were found under large flat rocks that are not imbedded in the substrate. Stream-banks were also searched for shell middens left by muskrats, *Ondatra zibethica*, that feed on mussels. All live, fresh dead (shiny nacre, evidence of meat left inside of shell), and relict (broken valves, stained nacre) mussels were identified to species and recorded on field data sheets. Individual specimens of all live and fresh dead mussel species were measured in millimeters (total length) for size-class distributional data using a digital dial caliper. The total amount of time sampling for mussels per site was recorded for determining quantitatively Catch Per Unit of Effort (CPUE). This method is used for determining how common or rare mussel species are based on the numbers of each species found during a timed search. Quantitative sampling using a 0.25 $m^2$ quadrat sample could not be used for determining mussel abundance because of the difficulty in sampling mussels under large rocks and the rarity of mussels found. Latitude and longitude were recorded using a hand-held Global Positioning System (GPS) unit and collecting sites were recorded by river mile location using U.S. Geological

Table 4— Freshwater mussel species found within the boundaries of the National Park Service, Obed WSR.

**Obed River**

| Mussels | River mile / Sampling hrs | 0.4 / 12.0 | 1.5 / 10.0 | 9.1 / 8.0 | 20.4 / 8.0 | 20.7 / 17.0 | 21.1 / 2.0 | 24.9 / 4.5 | 34.5 / 3.0 | Total / 64.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Elliptio dilatata* | | 30 | 8 | - | - | - | - | - | - | 38 |
| *Pleuronaia barnesiana* | | 1 | - | - | - | - | - | - | - | 1 |
| *Lampsilis cardium* | | 1 | - | - | - | - | - | - | - | 1 |
| *Lampsilis fasciola* | | 15 | 7 | 3 | 16 | 19 | 12 | 3 | - | 75 |
| *Medionidus conradicus* | | 35 | 45 | 1 | - | - | - | - | - | 81 |
| *Pleurobema oviforme* | | 1 | - | 2 | - | - | - | - | - | 3 |
| *Villosa iris* | | 6 | 8 | 2 | 2 | 7 | 6 | 3 | - | 34 |
| *Villosa perpurpurea* E | | 1 | 2 | - | 1 | 8 | 7 | - | - | 19 |
| Total | | 90 | 70 | 8 | 19 | 34 | 25 | 6 | 0 | 252 |

E Endangered

**Daddy's Creek**

| Mussels | River mile / Sampling hrs | 0.1 / 3.0 | 2.4 / 12.0 | - / - | - / - | Total / 15 |
|---|---|---|---|---|---|---|
| *Lampsilis fasciola* | | 2 | - | - | - | 2 |
| *Pleurobema oviforme* | | 2 | - | - | - | 2 |
| *Villosa iris* | | 4 | - | - | - | 4 |
| Total | | 8 | 0 | - | - | 8 |

**Clear Creek**

| Mussels | River mile / Sampling hrs | 1.6 / 2.0 | 4.5 / 4.0 | 8.7 / 5.0 | 14.8 / 2.5 | Total / 13.5 |
|---|---|---|---|---|---|---|
| *Lampsilis fasciola* | | - | 7 | 15 | 5 | 27 |
| *Villosa iris* | | 13 | 47 | 91 | 25 | 176 |
| Total | | 13 | 54 | 106 | 30 | 203 |

**Whites Creek**

| Mussels | River mile / Sampling hrs | 0.4 / 4.5 | - / - | - / - | - / - | Total / 4.5 |
|---|---|---|---|---|---|---|
| *Lampsilis fasciola* | | 4 | - | - | - | 4 |
| *Villosa iris* | | 108 | - | - | - | 108 |
| Total | | 112 | - | - | - | 112 |

**Emory River**

| Mussels | River mile / Sampling hrs | 27.4 / 7.0 | 27.8 / 4.0 | 28.5 / 3.0 | 28.7 / 1.5 | Total / 15.5 |
|---|---|---|---|---|---|---|
| *Lampsilis fasciola* | | - | 2 | - | - | 2 |
| *Potamilus alatus* | | - | 5 | 1 | - | 6 |
| *Villosa iris* | | - | 1 | - | - | 1 |
| Total | | 0 | 8 | 1 | 0 | 9 |

Survey 7.5-minute topographic maps. All mussel species were photographed and placed back into the substrate at the location where they were found. Representative single specimens of *Pleuronaia* (=*Fusconaia*) *barnesiana*, *M. conradicus*, and *P. oviforme* were collected as voucher specimens and taken to Dr. Paul Parmalee and deposited into the mollusk collections at the McClung Museum, The University of Tennessee, Knoxville. The collection of *P. barnesiana* is a new record for the Obed River. One live individual of endangered *V. perpurpurea* was collected under U.S. Fish and Wildlife Service federal permit, SA 00-14, and sent to Dr. Charles Lydeard, University of Alabama, Birmingham, for genetic sequencing. The genetic material from *V. perpurpurea* will be used for comparison with another closely related listed species *V. trabalis*, also reported from the Obed. This should clarify whether they are the same species, or separate.

## RESULTS AND DISCUSSION

Recent sampling produced 585 live mussels of nine species at 19 collecting sites (Tables 3-4, Fig. 1). A total of 113 person hours were spent sampling mussels and efforts varied between sites based on mussel habitat, number of mussels found and species diversity. The most abundant species found during the present study was *V. iris* that comprised 55% of all mussel species collected. This was followed in order of abundance: *L. fasciola* (19%), *M. conradicus* (14%), and *E. dilatata* (6%). The endangered *V. perpurpurea* represented 3% of the mussels found. Catch Per Unit Effort (CPUE) for all species is presented in Table 5. Shell-length measurement data are summarized by species for each stream sampled (Figs. 2-6) and summarized for the whole drainage (Fig. 7). Individual sampling results by stream are presented below.

### *Emory River*

Live mussels are present but rare in the upper Emory River below its confluence with the Obed River. Only three species were found in low numbers: *L. fasciola*, *P. alatus,* and *V. iris* (sites 1-4, Tables 3-4). The upper Emory borders the lower NPS boundary of the WSR. Large deposits of coal fines were observed on bedrock shoals and sand deposits along the banks of the river. Mussel habitat is extremely limited because of high stream gradient, deep pools, mostly bedrock and large boulder substrate, and coal fines. The few mussels found upstream of Nemo Bridge (site 1) occurred in cobble and sand pockets near rooted aquatic vegetation along the banks of the river. The fact that mussels were found at all in the Emory may be an indication

Table 5— Freshwater mussel species found in the upper Emory River Basin, percent composition (%), and Catch Per Unit Effort (CPUE).

| Species | Total | Percent | CPUE |
|---|---|---|---|
| *Elliptio dilatata* | 38 | 6.5 | 0.34 |
| *Fusconaia barnesiana* | 1 | 0.2 | 0.01 |
| *Lampsillis cardium* | 1 | 0.2 | 0.01 |
| *Lampsillis fasciola* | 110 | 18.8 | 0.97 |
| *Medionidus conradicus* | 81 | 13.8 | 0.72 |
| *Pleurobema oviforme* | 5 | 0.9 | 0.04 |
| *Potamilus alatus* | 6 | 1.0 | 0.05 |
| *Villosa iris* | 324 | 55.4 | 2.87 |
| *Villisa perpurpurea** | 19 | 3.2 | 0.17 |
| Totals | 585 | 100.0 | |

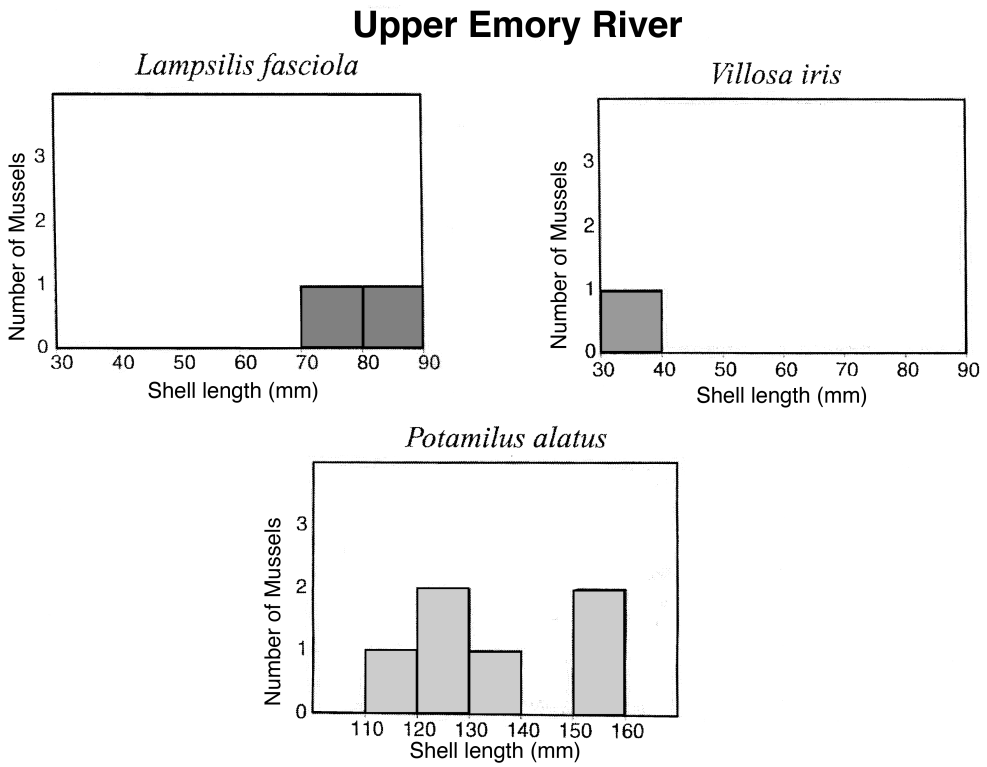


Figure 2— Summation of all shell-length measurement data for mussel species in the Emory River.

that water quality conditions are gradually improving over time. However, the small numbers of individuals found are represented by larger size-class individuals (Fig. 2) and mussel reproduction, recruitment, and recovery in the Emory is a long-term process. The river appears to be supporting its intended uses, including fish and aquatic life and has since been removed from the state's 305(b) list of impaired streams (Denton *et al*., 2000).

***Obed River***

A total of nine species were found in the Obed River: *E. dilatata, Pleuronaia barnesiana, L. cardium, L. fasciola, M. conradicus, P. oviforme, P. alatus, V. iris*, and *V. perpurpurea* (sites 5-12, Tables 3-4). Three species were reported as single individuals: *L. cardium* (live), *P. barnesiana* (fresh dead), and *P. alatus* (relict). Only three specimens of *P. oviforme* were found in the Obed and this species is extremely rare in the drainage. The most abundant species in the Obed in order of abundance: *M. conradicus* (81 individuals), followed by *L. fasciola* (75) and *E. dilatata* (38). It is unusual that *M. conradicus* would be the most abundant species because it is a relatively intolerant Cumberlandian endemic (restricted to the Tennessee and Cumberland River system) that is becoming increasingly rare throughout its known range. The species appears concentrated at the two lowermost sites (sites 5 and 6), and one site below the confluence of Daddy's Creek (site 7), where one individual was found. If large, flat rocks were not turned over during mussel sampling *M. conradicus* would probably not have been found. In general, mussels are relatively scarce in the Obed and federally listed *V. perpurpurea* (19

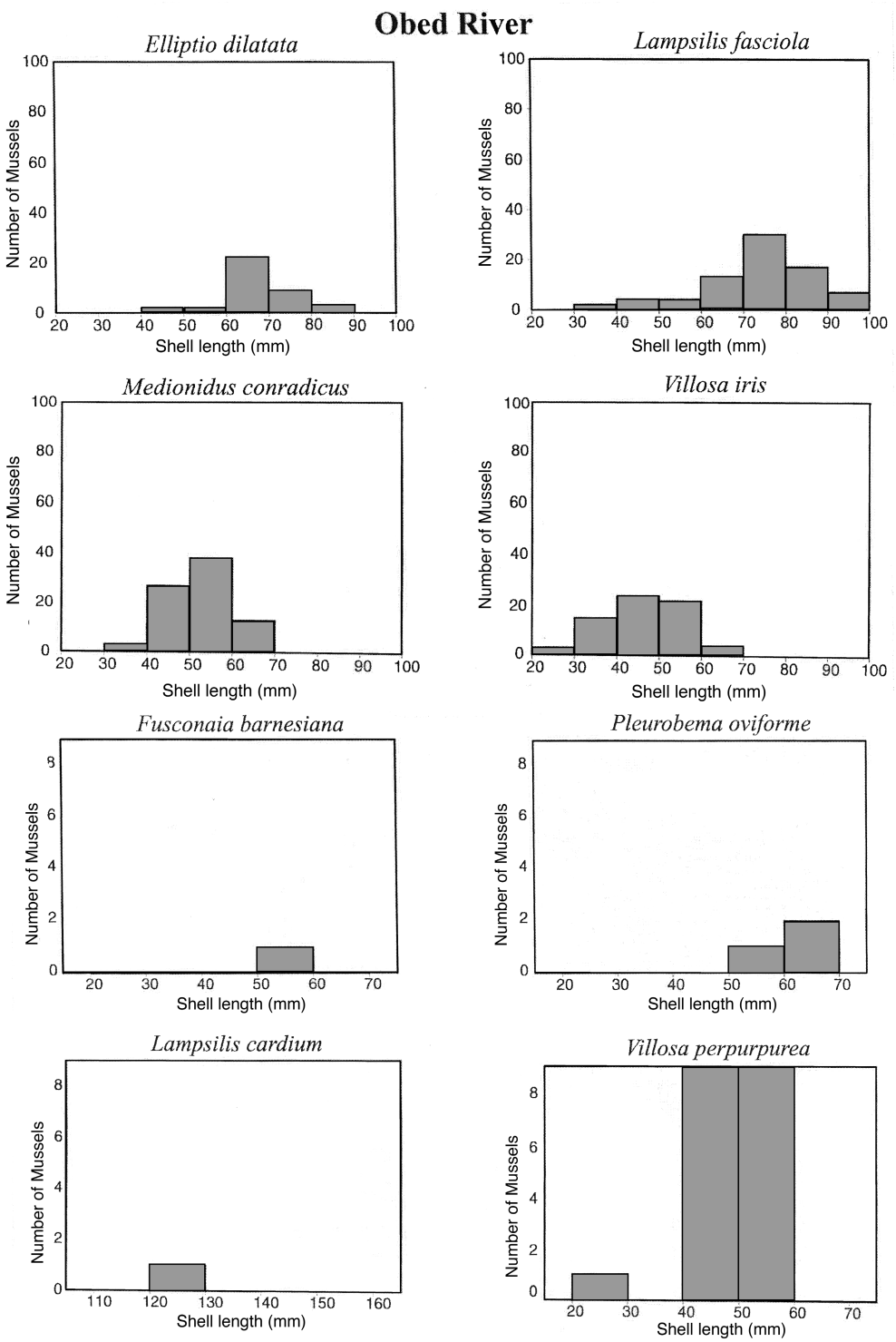


Figure 3— Summation of all shell-length measurement data for mussel species in the Obed River.

individuals) was found only in the middle reaches of the Obed, both upstream and downstream of Potter's Ford bridge (sites 8-10), and the two lowermost sites (sites 5 and 6) where the species is extremely rare. Considerable effort was made in sampling mussels in the Obed (64.5 person hours) Table 4, testimony to the overall rarity of mussels in the river.

Shell-length measurement data are skewed towards mostly larger adult mussels with very few individuals of *E. dilatata, L. fasciola, M. conradicus, V. iris*, and *V. perpurpurea* represented in the 20-50 mm size-class. This supports evidence that the small number of specimens found in the 20-50 mm range is indicative of lack of recent reproduction and recruitment to the fauna (Fig. 3). Externally, mussels showed evidence of considerable shell abrasion, the equivalent of being sand blasted. Habitat conducive for mussel colonization appears limited by the types of habitat found in high gradient Plateau streams (i.e., bedrock, boulders, with pockets of sand and gravel), and the biologically unproductive nature of sandstone and shale. River conditions for mussel colonization and survival are further exacerbated during low-flow conditions by heavy concentrations of blue-green and filamentous algae that cover the substrate. The problem extends throughout the length of the Obed and may originate from many sources outside the boundaries of the WSR. It remains unknown what and where the sources are for nutrient enrichment; however, one site sampled for mussels in the headwaters outside the boundaries of the WSR (site 12) upstream from Interstate 40 bridge-crossing near Crossville found no evidence of mussels in the river. The Obed River at this point was heavily silted and covered with algae originating from Black Drowning Creek. Substrate in the creek was observed to be completely covered over in algae (both attached and filamentous). In contrast, the Obed River above its confluence with Black Drowning Creek was crystal clear. In recent conversations with Fran Baker, Tennessee Department of Environment and Conservation (TDEC), he reported that dairy farm wastes originating from Black Drowning Creek are a major source of nutrient enrichment in the Obed. Black Drowning Creek is on the state's 305(b) list for impaired waters and includes approximately 3.2 miles (5 km) of the Obed. The causes for impairment in the Obed are listed as urban runoff, storm sewers, and upstream impoundments (Denton *et al*., 2000). The City of Crossville's sewage treatment plant was responsible for past wastewater discharges into the Obed and cited for numerous water quality violations prior to 1998. This problem has since been corrected but the sewage treatment plant at Fairfield Glade retirement community is presently in violation (F. Baker, pers. comm.).

### *Clear Creek*

Only two mussel species, *L. fasciola* and *V. iris*, were found at four collecting sites in Clear Creek (sites 13-16, Tables 3-4). *Villosa iris* is the more common of the two and represented by many individuals in the 20-70 mm size-classes. This is an indication of some recent reproduction and recruitment for this species. Only larger size-classes of *L. fasciola* were found (50-90 mm), and this species may not be recruiting in Clear Creek (Fig. 4). However, smaller individuals may be present but low stream flows and concentrations of filamentous algae hampered finding mussels. Mussel habitat is limited because of high stream gradient, and boulder and bedrock substrate. Most mussels were found in pools in pockets of sand and gravel, and along the edges of streamside aquatic vegetation. Many specimens of *V. iris* were found under large flat rocks. The scarcity of other mussel species indicates that the drainage as a whole may never have supported a greater diversity of mussels. Both mussel species found in Clear Creek are common elements of small streams.

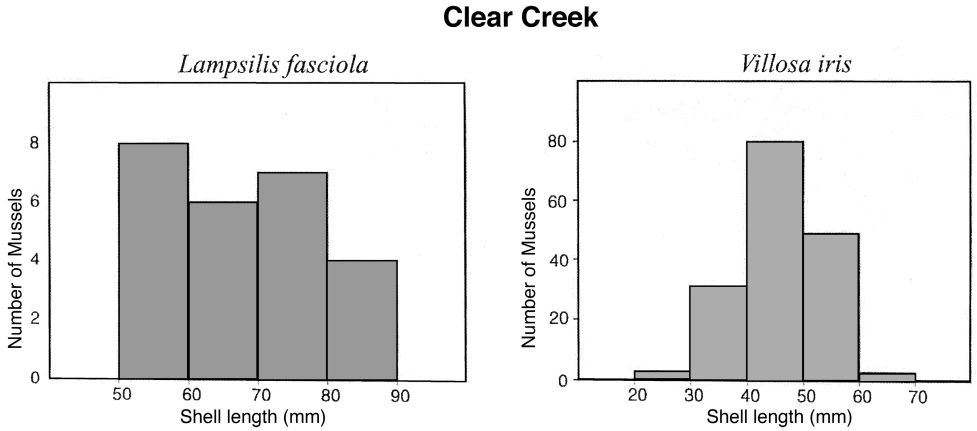


Figure 4— Summation of all shell-length measurement data for mussel species in Clear Creek.

### *Whites Creek*

One site was sampled in Whites Creek at Whites Ford (site 17, Tables 3-4). Whites Creek is a tributary stream that flows into Clear Creek just upstream from Barnett Bridge. Two mussels occur here, *L. fasciola* and *V. iris*, and *V. iris* is the more common of the two. More specimens of *V. iris* were found here than at any of the other 19 sites sampled in the upper Emory River basin. Smaller size-class individuals of *V. iris* (20-30 mm), represent recent reproduction and recruitment to the fauna (Fig. 5). However, mussel habitat is very limited in Whites Creek because of boulder substrate. All mussels that were found occur along the edges of pools in pockets of sand and gravel, and near streamside aquatic vegetation. Habitat is almost identical to what was observed in Clear Creek except filamentous algae was not as prevalent.

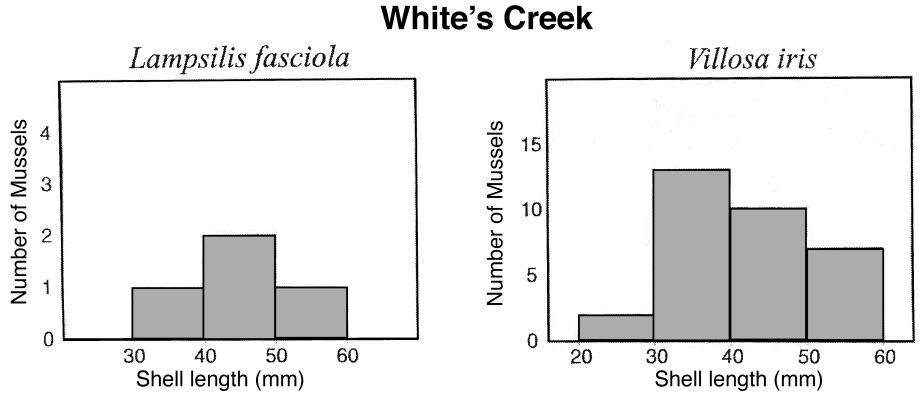


Figure 5— Summation of all shell-length measurement data for mussel species in the Whites Creek.

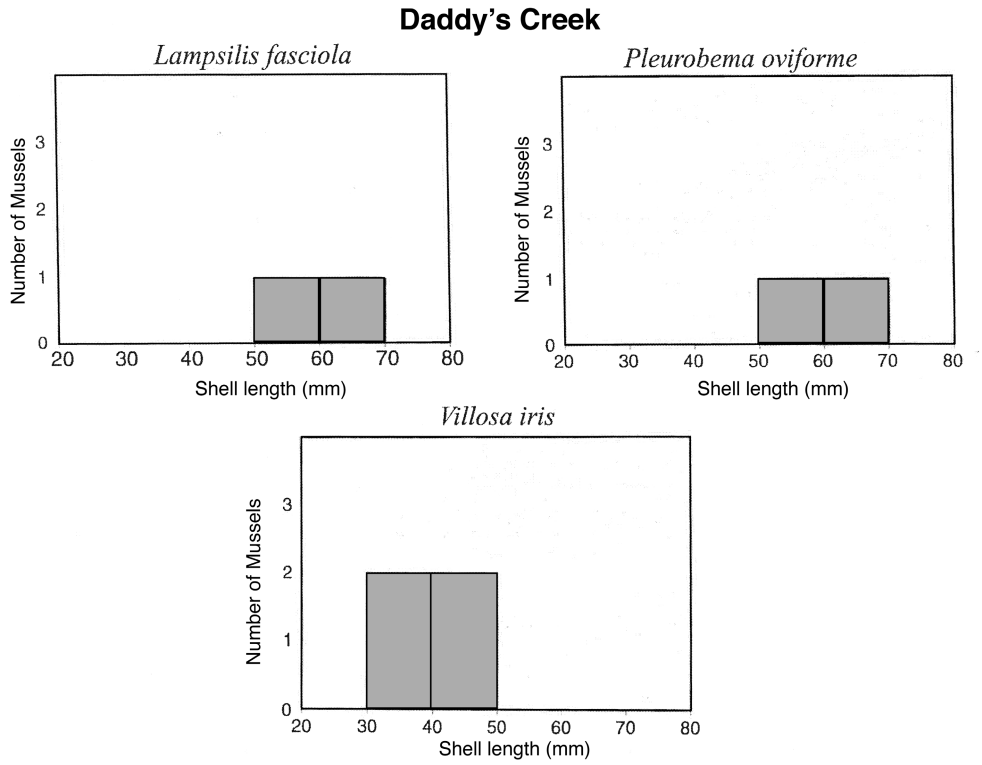


Figure 6— Summation of all shell-length measurement data for mussel species in Daddy's Creek.

***Daddy's Creek***

Three mussel species, *L. fasciola*, *P. oviforme*, and *V. iris*, were reported live but rare in Daddy's Creek (sites 18-19, Tables 3-4). No mussels or shell fragments were found at Devil's Breakfast Table (site 19), and mussels were found only in the lower end of the creek near its confluence with the Obed. Mussel habitat is extremely limited by high stream gradient, bedrock, and boulder substrate. The few mussels that were found occur under large flat rocks. Additional mussels may still be present in Daddy's Creek (based on historical records) but the lower collecting site on the creek was completely covered over in filamentous algae that made sampling difficult. Mussels are rare in Daddy's Creek and it is doubtful that mussels will continue to exist because of the low numbers found and larger size-classes for all three species (Fig. 6). Daddy's Creek is the only stream other than the Obed where live *P. oviforme* occurs. Based on H. T. Athearn's 1968 mussel records from the same sampling location in this study (site 18), he reported six species in good numbers including *F. subrotunda* and *V. vanuxemensis*. Both species are apparently extirpated from the upper Emory River basin. The mussel fauna in the creek appears to have taken a downward turn since 1968.

## CONCLUSIONS

Pre-historical 1970, and recent post-1970 mussel collections have documented 27 species in the Emory River basin. Within the upper Emory River basin including tributary streams

within the NPS park service boundaries of the Obed WSR, 12 mussel species are reported since the mid-1960s. Nine were found during the present study, and two species *P. barnesiana* and *L. cardium*, were represented as single individuals, and only five *P. oviforme* were found. One species, *P. barnesiana*, is a new distribution record for the Obed, and specimens of *M. conradicus*, *P. oviforme*, and *P. barnesiana* are deposited with the mollusk collections at the McClung Museum, The University of Tennessee, Knoxville. Three species are questionable as to their identifications: *Actinonaias* spp., *F. flava,* and *V. trabalis*. The 1988 relict specimen of *Actinonaias* may have actually been a large *L. cardium* since no *Actinonaias* spp. are known from the Obed or Emory River. The 1988 record for *F. flava* is questionable in the Obed based on two eroded relict individuals. This mussel has never been documented in eastern Tennessee and only occurs in middle and western Tennessee streams (Parmalee and Bogan, 1998). Records from 1968 of *V. trabalis* in the Obed and Daddy's Creek are questionable because both *V. trabalis* and *V. perpurpurea* have the same external shell characteristics in color, shape, and ray patterns that are present in live specimens. Identifying characteristics that separate both species are based on the inside nacre color of the shell in dead individuals: *Villosa trabalis* is white, and *V. perpurpurea* is purple. Color of the nacre can be determined in some live specimens only if the white or purple color of the nacre shows through the umbo (hinged portion of the shell) on eroded specimens. Live and fresh dead individuals observed in the Obed during the present study were identified as *V. perpurpurea* based on purple nacre. Both species are federally listed and tissue samples are presently being genetically sequenced by Dr. Charles Lydeard, University of Alabama, Birmingham. Sequencing should resolve whether both are valid species or represent a single species.

The total number of mussel species that may have been present in the lower and upper Emory River basin remains unknown. The low productivity of streams draining the Cumberland Plateau versus the more productive streams of the Ridge and Valley is probably an indication that there never was a diverse mussel fauna. A few additional mussel species may have occurred here given that both small stream species (*P. barnesiana*, *M. conradicus*, *V. iris*, *V. perpurpurea*) and mid-large river species (*L. cardium*, *F. subrotunda*, and *P. alatus*) are documented. No evidence suggests that additional species historically occurred here.

A summation of all shell-length data for all streams sampled in the upper Emory River basin shows evidence of some mussel reproduction and recruitment based on smaller size-class individuals, especially *V. iris* (Fig. 7). Unfortunately, smaller size-class individuals in the 20-40 mm range for *L. fasciola*, *M. conradicus*, and *V. perpurpurea* are represented by a few individuals. Reproduction and recruitment appears minimal for these mussels and three, *P. barnesiana*, *L. cardium*, and *P. oviforme*, are rare entities to the fauna that may no longer be functionally reproductive.

Of concern is the number of sampling hours required to find mussels and low CPUE for all species except *V. iris* (Table 5). Mussel habitat is severely limited because of the high stream gradient and unsuitable substrate consisting of large boulders and bedrock. The only stable areas available for mussels to colonize were under large, flat rocks or around the edges of stream-bank vegetation. In shoals that contained a good mixture of cobble, gravel, and sand, mussels were still rare. Filamentous and attached algae cover the substrate in many areas. The problem is magnified by low flow regimes that are typical today for Cumberland Plateau streams. Historically, higher flow patterns may have been maintained at much higher levels over millennia than during present conditions. Human activities outside the boundaries of the WSR will continue to influence the quality and quantity of water and biological communities that exist within its boundaries.

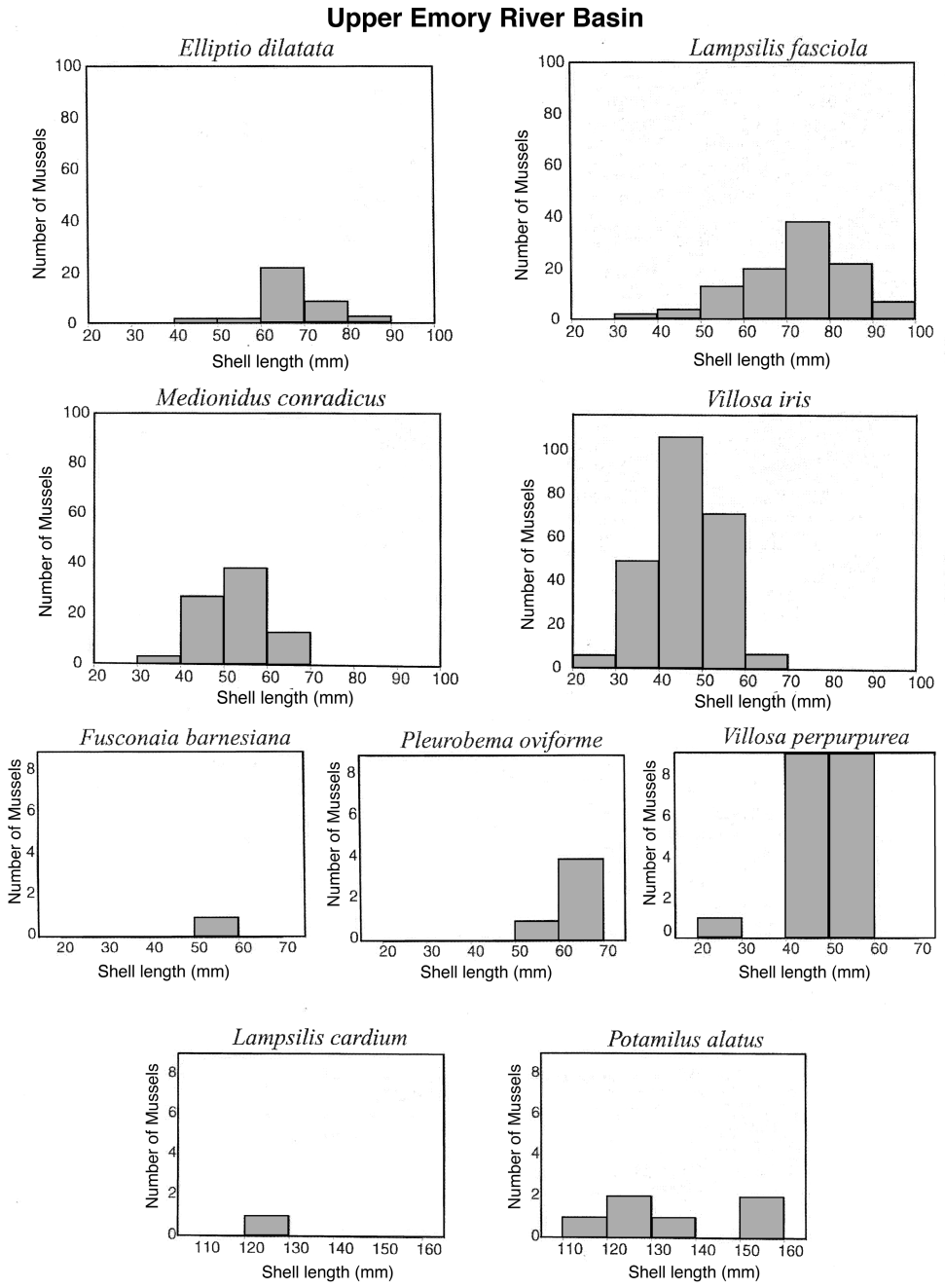


Figure 7— Summation of all shell-length measurement data for mussel species in the upper Emory River basin including Obed River, Clear Creek, Whites Creek, and Daddy's Creek.

## RECOMMENDATIONS

The freshwater mussel fauna in the Obed WSR should be monitored bi-annually at two sites at middle and lower reaches of the river. The best area found for the endangered *V. perpurpurea* occurs in the area upstream of Potters Ford Bridge and the most biologically diverse site for mussels occurs at the lowermost shoal upstream from the rivers confluence with the Emory River. The goals are to continue monitoring these sites using techniques established during the present study and establish trend information on whether mussels are increasing or declining over time.

The *V. perpurpurea* populations in the Obed are critical for the survival of the species as a whole and represents one of four known populations. The probability exists that this species can be propagated and populations augmented in the Obed to keep its presence in the river until water quality problems are corrected. This species has been propagated at Virginia Tech's Freshwater Mollusk Conservation Center (FMCC) at Blacksburg, Virginia under the direction of Dr. Richard Neves. Cohorts produced were released to augment existing populations in Virginia where this species occurs. Propagation of federally listed species and augmentation of existing populations are in direct compliance with actions outlined in recovery plans prepared by the U.S. Fish and Wildlife Service.

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