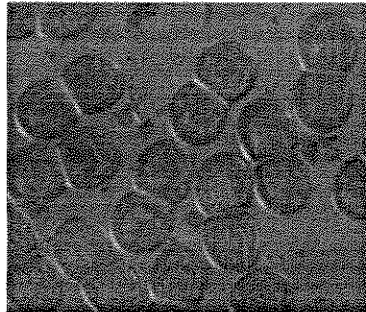


McGregor
2005

MICHAEL J. NEVES

**FRESHWATER MOLLUSK CONTROLLED PROPAGATION PLAN FOR
KENTUCKY DEPARTMENT OF FISH AND WILDLIFE RESOURCES**



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INTRODUCTION

Freshwater mussels are the most at-risk group of animals in North America. Of the 297 native mussel species in the United States, 71.7% are considered endangered, threatened, or of special concern, including 21 mussels that are endangered and presumed extinct (Williams et al. 1993). Seventy species (23.6%) are considered to have stable populations, although information is lacking for many of these species. Mussel and host fish populations are projected to decline if habitats are not restored and individual species numbers increased.

Modern day threats to mussels include habitat destruction from a variety of factors, including: sedimentation from agricultural land, logging and mining operations, construction projects, stream channelization and dredging, toxic spills (oil, gas, industrial acids, pesticides, fertilizers) and resulting fish kills, and invasion from exotic species (Parmalee and Bogan 1998). With the low numbers of mussels and continuing population declines, protecting each stage in the life cycle of the mussel is critical. Vital life stages include the availability of fish hosts, production of juveniles (currently inhibited by low density levels), and juvenile survival. Sufficient habitat is necessary for grow-out of juveniles to the adult stage. Good water quality and habitat are important to all stages of development, especially so for the larval and juvenile stages.

The mussel fauna in Kentucky is represented by the Mississippian or Interior Basin, the Cumberlandian, and Atlantic Slope Faunal groups (Figure 1). The Interior Basin faunal area includes the whole Mississippi River Basin minus the Ozarkian and Cumberlandian faunal areas (Bogan and Parmalee 1998). In Kentucky, the Mississippian fauna can be divided into the Mississippi River mainstem

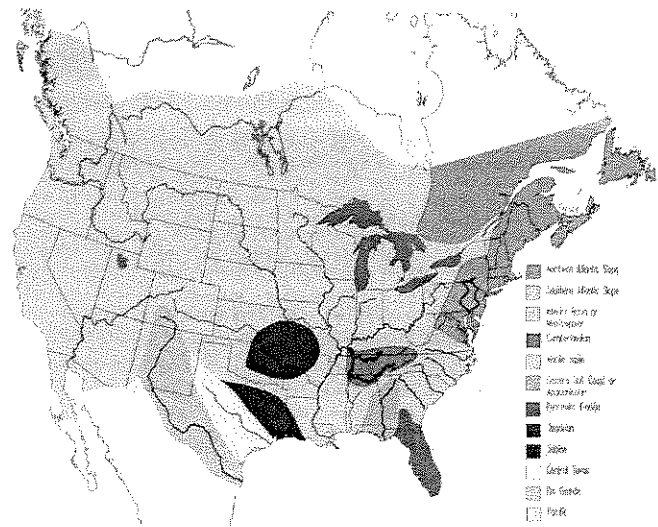


Figure 1. Unionid provinces in North America (Parmalee and Bogan 1998).

(and its minor tributaries) and the tributaries (including the Ohio River & tributaries minus the Cumberland and Tennessee Rivers). The Cumberlandian fauna encompasses the Tennessee and Cumberland River systems. Each faunal area contains specific species assemblages: the Mississippian fauna consists of ~80 species (5 extinct and 14 FE) (Mississippi mainstem fauna has ~22 species (none listed); the Cumberlandian fauna has ~22 species (7 extinct and 8 FE); the Atlantic Slope has one species (none listed). Overall,

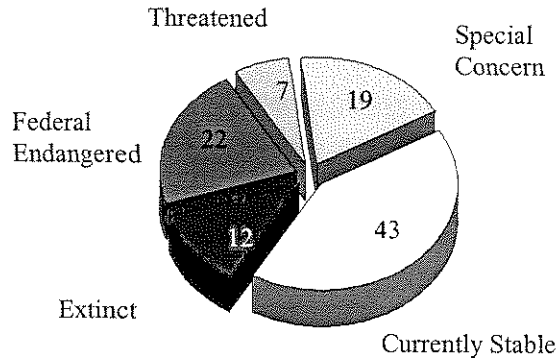


Figure 2. Status of the mussels found in Kentucky.

Kentucky has one of the most diverse mussel populations in North America with 41 genera and 103 recognized species (see Appendix Table 1) (Cicerello et al. 1991; Gordan and Layzer 1989). Twelve mussels are presumed extinct (Figure 2), and another 22 (Table 1) are listed by the U.S. Fish and Wildlife Service as endangered (at least 8 of the 22 are considered extirpated from the state) (Williams et al. 1993, Cicerello et al. 1991).

Due to recent advances in technology and interests in proactive recovery of freshwater mussels, the Kentucky Department of Fish and Wildlife’s Wildlife Diversity Program has started an Aquatic Restoration Initiative to restore and recover the highly imperiled freshwater habitats and its native fauna. Kentucky has over 89,000 miles of rivers and streams located in multiple geological provinces (Figure 3). Approximately 55 percent of Kentucky’s land is underlain by karst topography and therefore supports the necessary hard water for mussel shell construction. With significant mussel and fish populations in many of the state’s river systems

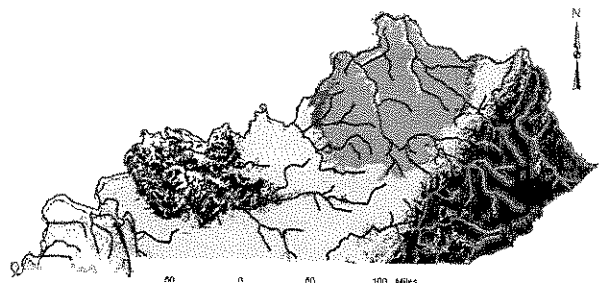


Figure 3. Generalized geological map of Kentucky with major streams and rivers.

(e.g., Mississippi, Ohio, Tennessee, Cumberland, Green, and Licking Rivers), the potential to augment existing areas with low population numbers is high.

GOAL AND OBJECTIVES

The goal of this program is to recover imperiled mussels and to restore freshwater mollusk biodiversity and associated ecological functions to appropriate reaches of the rivers and streams in the Ohio and Mississippi River drainages. The objectives of this plan are to:

- 1) establish protocols for holding and propagating mollusks,
- 2) ensure communication and coordination among partners prior to relocation of wild stock, or the release of hatchery stock to the wild, and,
- 3) facilitate mollusk augmentation, expansion, and reintroduction activities in the Ohio and Mississippi River drainages, primarily through captive propagation.

Success of captive mollusk propagation efforts will

- 1.) reduce or alleviate risk of extinction,
- 2.) restore extirpated populations, and
- 3.) rebuild low population numbers via augmentation

Table 1. Federal listed endangered and candidate freshwater mussels in Kentucky identified for propagation and recovery efforts. Common name and subfamily from Turgeon et. al (1998) .

<u>SPECIES in Kentucky</u>	<u>Common Name</u>	<u>Subfamily</u>	<u>status</u>
<i>Alasmidonta atropurpurea</i>	Cumberland elktoe	Anodontinae	FE
<i>Cumberlandia monodonta</i>	spectaclecase	Margartiferidae	FC
<i>Cyprogenia stegaria</i>	Fanshell	Lampsilinae	FE
<i>Dromus dromas</i>	Dromedary pearlymussel	Lampsilinae	FE
<i>Epioblasma brevidens</i>	Cumberlandian combshell	Lampsilinae	FE
<i>Epioblasma capsaeformis</i>	oyster mussel	Lampsilinae	FE
<i>Epioblasma florentina walkeri</i>	tan riffleshell	Lampsilinae	FE
<i>Epioblasma obliquata obliquata</i>	Catspaw	Lampsilinae	FE
<i>Epioblasma torulosa gubernaculum</i>	Greenblossom, (pearlymussel)	Lampsilinae	FE
<i>Epioblasma torulosa rangiana</i>	Northern riffleshell	Lampsilinae	FE
<i>Hemistena lata</i>	Cracking pearlymussel	Pleurobeminae	FE
<i>Lampsilis abrupta</i>	pink mucket	Lampsilinae	FE
<i>Leptodea leptodon</i>	Scaleshell	Lampsilinae	FE
<i>Obovaria retusa</i>	ring pink	Lampsilinae	FE
<i>Pegias fabula</i>	Littlewing pearlymussel	Anodontinae	FE
<i>Plethobasus cicatricosus</i>	white wartyback	Pleurobeminae	FE
<i>Plethobasus cooperianus</i>	orange-foot pimpleback	Pleurobeminae	FE
<i>Pleurobema clava</i>	clubshell	Pleurobeminae	FE
<i>Plethobasus cyphus</i>	sheepnose	Pleurobeminae	FC
<i>Pleurobema plenum</i>	rough pigtoe	Pleurobeminae	FE
<i>Potamilus capax</i>	fat pocketbook	Lampsilinae	FE
<i>Ptychobranhus subtentum</i>	fluted kidneyshell	Lampsilinae	C
<i>Quadrula fragosa</i>	winged mapleleaf	Ambleminae	FE
<i>Villosa fabilis</i>	rayed bean	Lampsilinae	
<i>Villosa trabilis</i>	Cumberland bean	Lampsilinae	FE

ROLE OF CONTROLLED PROPAGATION: coordinate with habitat management and restoration programs and use when other methods to recovery species have failed.

JUSTIFICATION FOR CONTROLLED PROPAGATION

The Mississippi and Ohio River Basins in and near the geographic boundaries of Kentucky contain some of the highest diversity of freshwater mussels in the world. Major obstacles to recovery of mollusks in Kentucky are the fragmentation and isolation of river habitats by dams and impounded waters and/or pollution. Most imperiled mollusks now occur in only a few localized reaches, or in some cases at a single site (e.g., *Pegias fabula*, *Epioblasma walkeri*, *Obovaria retusa*, *Plethobasus cicatricosus*). Some isolated stream reaches where mollusks were extirpated due to historical pollution events or other temporally isolated causes, have now improved to a degree that mussels may now survive (e.g., Big South Fork Cumberland River, Upper Green, Lower Licking River) and reproduce. However, dams and/or extensive areas of impounded waters prevent re-colonization and natural gene flow through the processes of immigration and emigration. Some species have become exceedingly rare, with apparently low reproductive and recruitment success (e.g., *Pegias fabula*, *Obovaria retusa*). Such species often require extensive sampling efforts to locate in the wild for use in recovery. Isolated mollusk populations are subject to inbreeding depression and stochastic events. Limited information is available on mussel & host fishes (e.g., *Obovaria retusa* *Pleurobema plenum*) and the life history requirements of both mussels and host fishes, especially from a propagation perspective. Because of these conditions, human intervention is required to understand, manage, and restore populations of endemic aquatic species, including:

- developing technology and facilities for holding endangered and threatened mollusks,
- producing captive reared individuals for research and technology development,
- in some cases, establishing and maintaining captive populations of endangered mollusks,
- producing individuals for supplementing (augmenting) existing populations, and
- producing individuals for reintroduction of species into restored or recovered habitats.

The U.S. Fish and Wildlife Service (FWS) has been working with State and private partners to locate populations of rare mussels and snails in Kentucky, and more recently, to develop appropriate protocols and facilities for holding and propagating mussels. As a result, Kentucky

Department of Fish and Wildlife Resources is at a point where progeny of federally protected and rare mussels can be produced in hatchery facilities in excess of the numbers required to maintain the captive population. This plan serves as the necessary documentation of USFWS policy requirements in the development of a reintroduction plan prior to the release of propagated endangered and threatened species into the wild (Fed. Register 2000).

PARTNERS

The State of Kentucky has identified multiple partners, including (but not limited to) U.S. Fish and Wildlife Service, Universities (Eastern Kentucky University, Murray State University, University of Kentucky, Kentucky State University, Tennessee Technological University), Daniel Boone National Forest, Mammoth Cave National Park, The Nature Conservancy, Tennessee Wildlife Resources Agency Kentucky State Nature Preserves Commission, U.S. Forest Service (FS), U.S. Geological Survey (USGS), U.S. Army Corps of Engineers, and others have been cooperating in studies of the Basin's endemic mussel life histories, and in developing holding and propagation technology for several species. Live mussels are currently held and used for life history research at the Center for Mollusk Conservation (Frankfort, KY). See appendix more a detailed list of partners.

DEFINITIONS

The purpose of these guidelines is to provide a structure to the process of increasing populations of endangered mussels in the wild. All endangered species recovery plans recommend the introduction of the each species as a task towards delisting. In this document there are three levels of introduction; augmentation, expansion, and reintroduction. Each level establishes varying degrees of effort and contacts.

Level 1: Augmentation - release of species at a reach where the species currently exists in low numbers.

- A) Augmentation reach must be thoroughly surveyed to determine presence of target species. Species must already be present within the augmentation reach.

- B) Augmentation can occur by 1) the translocation of adult mussels from a source population, 2) release of newly metamorphosed juveniles, or 3) release of infected host fishes collected from the augmentation reach. Source population must contain sufficient numbers so that it would be unaffected by the removal of a few specimens.
- C) When stocking adults or when the recipient population is too small to adequately supply adults for artificial propagation, the specimens will come from another population using the following criteria:
- 1) Stock from another metapopulation in the same stream/tributary system in the same physiographic province.
 - 2) Stock from another population in an adjacent stream/tributary system in the same physiographic province.
 - 3) Stock from another population in an adjacent stream/tributary system in an adjacent physiographic province.
 - 4) Stock from the only population known.

Authority - Augmentation will be based on the decision of Department biologists. Because species are extant in the reach, no additional regulations or special designations would be needed.

Level 2: Expansion - release of species into suitable historical habitat in a reach where the species is currently extirpated but exists upstream or downstream and can migrate to naturally.

- A) Recipient reach must be thoroughly surveyed to determine absence of target species. If target species are found, use Level 1 justification.
- B) Expansion can occur by 1) translocation of adults from a source population, 2) release of newly metamorphosed juveniles or 3) release of infected host fishes collected from recipient reach. Source populations must contain sufficient numbers so that it would be unaffected by the removal of a few specimens.

D) When stocking adults or producing juveniles, the source should be from a population using the following criteria:

- 1) Stock from another metapopulation in the same stream/tributary system in the same physiographic province.
- 2) Stock from another population in an adjacent stream/tributary system in the same physiographic province.
- 3) Stock from another population in an adjacent stream/tributary system in an adjacent physiographic province.
- 4) Stock from the only population known.

Authority: Stocking of mussels will be based on the decision of Department biologists and the recommendations of the Controlled Population Guidelines. Because species could potentially migrate to target reach naturally, no additional regulations or special designations would be needed.

Level 3. Reintroduction - release of species into suitable historical habitat in a reach where they are currently extirpated and cannot migrate to naturally.

- A) Recipient reach must be thoroughly surveyed to determine absence of target species. Species must have been historically documented in the recipient reach.
- B) Reintroduction of species can occur by 1) translocation of adults from source population, 2) release of newly metamorphosed juveniles or 3) release of infected host fishes collected from recipient reach/drainage. Source populations must contain sufficient numbers so that it would be unaffected by the removal of a few specimens. Stocking of species should use the following criteria:

- 1) Stock from another population in the same stream/tributary system in the same physiographic province.
- 2) Stock from another population in an adjacent stream/tributary system in the same physiographic province.

- 3) Stock from another population in an adjacent stream/tributary system in an adjacent physiographic province.
- 4) Stock from the only population known.

Authority: Because species has not occurred in the recipient reach for an extended period of time, the decision to reintroduce must be coordinated by Department biologists and affected groups, such as regulatory authorities and/or landowners. Reintroduced population may need special designations such as “experimental” or “nonessential.”

CONTROLLED PROPAGATION

The biology, life history and genetics of many of Kentucky’s mollusk species are poorly known. Only a few attempts have been successfully made to propagate any of these species in captivity. Therefore, controlled propagation will be treated as experimental in nature, and will require detailed proposals prior to issuance of appropriate permits. In general, any parties wishing to conduct controlled propagation of mollusks must abide by the following guidelines:

- present a detailed plan to the KDFWR and the USFWS (listed species) outlining their expertise, facilities and methodology, species to be propagated, source of stock, disposition of progeny, etc.; an Environmental Assessment may also be necessary;
- provide justification for the work, including benefits;
- obtain all necessary State and Federal permits;
- take all necessary precautions to prohibit the potential introduction or spread of diseases, parasites, and exotic species (e.g., zebra mussels) into controlled environments or suitable habitat;
- conduct all activities in a manner that will prevent the escape or accidental introduction of individuals outside of their historical range; and,
- keep detailed notes and records of life history observations, fecundity, survival and mortality, water chemistry, seasonality, and any other conditions/observations important to successful propagation of these species.

POPULATION AUGMENTATION, EXPANSION, OR REINTRODUCTION

Although many streams in Kentucky have been highly modified, a number of opportunities exist to improve mussel populations through controlled augmentation, expansion, or reintroduction. Propagation activities have not been attempted for many of the species in Kentucky beyond the research phase, and should be considered as individual experiments. In order to protect genetic integrity, biological diversity, and to avoid conflicts, all activities will be coordinated with all appropriate Recovery Partners (i.e., USFWS, State agency, riparian landowner, affected Federal agency).

SITE PLANS

Partners wishing to plan, sponsor, or conduct specific actions will produce a Site Augmentation/Expansion/Reintroduction Plan (Site Plan) prior to conducting any activities. Site Plans for potential activities will be developed and distributed to the appropriate FWS Field Office(s) and Regional Office prior to propagation. It is understood that collection of gravid females, successful production of progeny, number of progeny produced, etc. is difficult to predict. However, Site Plans should include as much information as possible, including:

- the exact location where animals are to be introduced,
- status of the target species at the site, and why propagation is necessary,
- an Alternatives Plan (e.g., no action),
- relationship of the site to other populations of the target species,
- current habitat conditions at the site,
- possible limiting factors at the site (e.g., recruitment, fish hosts presence and abundance)
- source of the animals for activity (adults, juveniles, hatchery-produced, or wild),
- source of the stock (location and drainage),
- monitoring plan and responsibilities,
- cooperating and responsible partners,
- a copy of all appropriate permits, and,
- any other pertinent information.

All Recovery Partners, and any other affected private or public entity identified by the Partners, will be notified of planned activities, and will be provided upon request with the Site Plan prior to relocating or releasing animals in the wild.

Site Selection

Sites for augmentation/expansion/reintroduction activities should be selected based on criteria identified above, including historical and current distribution of the species, habitat conditions (e.g., water quality, recruitment, fish hosts), and past, present or future threats. Since methods are experimental in nature, activities for a species or suite of species should be restricted to discrete sites within a drainage. The site should be used and monitored for a period of years, or until there is evidence of success or failure. Concentrating efforts at a site will reduce monitoring costs and facilitate genetic modeling.

Monitoring

Since methods are experimental in nature, monitoring is critical to determine effectiveness and/or success of such programs. The facility and/or Partner conducting the release is responsible for developing and conducting a monitoring plan, unless otherwise specified in the Site Plan.

Stock

Transplantations of subadult or adult mollusks should come from locally robust populations. Removal of mollusks for transplantations should affect less than 5% of the donor population if possible. Adults taken for propagation should represent various age and size classes to ensure genetic diversity. Based on recent work, KDFWR recommends a minimum of 10-12 males and 10-12 females (total of 20-24 individuals) of each species to initiate spawning in captivity. However, biologists have observed glochidia production with as few as one female and three males with multiple species. Some species may require more or less individuals based on population genetics. Hatchery progeny used for augmentation should come from parental stock in the drainage nearest to the augmentation site, whenever possible. It is recommended that

donor populations come from the specific site or as close as possible to the site. If females can not be obtained from the site, upon recommendations by partners, adults may be collected from an adjacent site in the same minor drainage, a secondary site in the same drainage, or from the only source available if necessary (see definitions section for more details).

Reporting

Recovery Partners conducting hatchery propagation studies, augmentation or reintroduction releases, or release monitoring studies will provide an annual report of activities to the KDFWR and other involved partners, including:

- a brief description of their propagation program, including objectives and status,
- list of cooperators, if any,
- activities conducted, prospects for, or obstacles to achieving their research, propagation, or reintroduction efforts, and,
- a brief description of the status of targeted populations, if any.

GENETIC CONSIDERATIONS

Very little is known of genetic differences between drainage populations of the mollusk species, as they relate to expressions in morphology, behavior, and other forms of habitat adaptation. As such, it is preferred that stock for propagation should come from the same drainage as the proposed release site. Geneticists recommend that up to 50 females may be necessary to provide the necessary offspring for maintaining genetic diversity. However, most rare mussel populations do not support sufficient numbers to accomplish this task. Therefore, KDFWR recommends the use of at least three females for propagation purposes if possible. In cases where only a single known population of a once wide ranging species is known to survive, or where a drainage population has been severely reduced or extirpated, genetic issues are not of immediate concern.

Juveniles produced in a hatchery by a single female mussel may number in the hundreds to thousands. Juvenile mussel mortality after release is believed to be extremely high, with only a small fraction of released juveniles surviving to maturity. Natural mortality and survival in the wild is difficult to establish.

In order to minimize any potential of inbreeding affects, it is preferred that hatchery produced juveniles from a specific female mussel will only be used once per site. Gravid mussels used to produce juveniles for stocking will be uniquely marked and returned to the point of capture. Subsequent releases should come from other appropriate wild mussel stock whenever possible.

DISPOSITION OF EXCESS PROGENY FROM RESEARCH ACTIVITIES

Various partners periodically conduct laboratory host-fish trials with endangered and threatened mussels. Propagation efforts or host fish trials may result in excess juvenile mussels. Larger numbers of research or hatchery-produced offspring should be considered for:

- augmentation or reintroduction releases,
- toxicity testing, or
- other existing experimental needs.

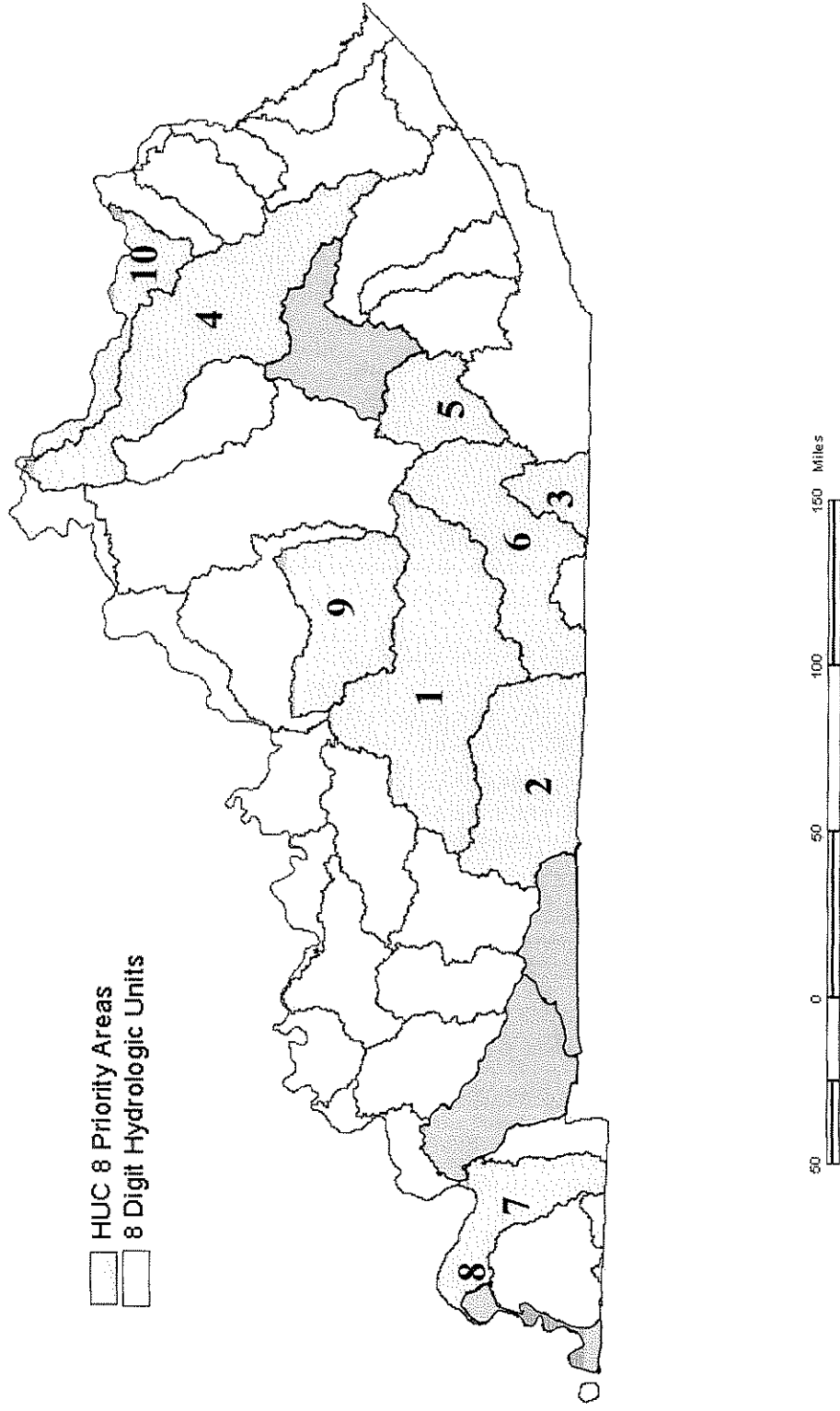
Small numbers of juvenile mollusks, excess individuals, or specimens rendered unfit for population augmentation or reintroduction to historical habitats that result from research activities can be properly preserved for genetic testing (e.g., ethanol or frozen), appropriately labeled, and deposited in appropriate facilities.

Priority Areas Selected for Augmentation/Expansion/Reintroduction

Select areas (priority management units with boundaries defined by HUC 14) in Kentucky have been identified based on presence of imperiled mussels as the most appropriate areas for augmentation, expansion, and reintroduction (Figure 4, Tables 2, 3, & 4). Additional priority management units may be identified as more information becomes available through the review process. Each priority management unit will be reviewed and ranked based on the level of conservation priority for each species and the cumulative diversity of rare species within the unit (see Table 5). Once specific sites within the priority management unit have been selected, those sites with multiple rare species are ranked higher than sites with low diversity. All management units in Kentucky were divided into hydrologic units based on 8 digit and 14 digit HUC. Species richness was identified within each of the HUC units and prioritized based on the level of richness. We identified ten HUC 8 (larger watersheds) priority management units and several

HUC 14 (smaller units) within the larger HUC 8. The highest HUC 8 was labeled Priority Management Unit 1 and had four smaller units (either HUC 14 or a combination of adjacent HUC 14s) labeled 1a, 1b, 1c, and 1d. These ten Priority Management Units support most of the freshwater mussel richness in Kentucky. However, species may also be ranked based on status, culture capability (e.g., host known, handling sensitivity, fecundity, number of donor females, fish host sensitivity), costs, and other (see Table 6). In the case of extremely rare animals (i.e., present at only one site), it may be necessary to hold brood stock in captivity for expansion purposes.

Bivalve Priority Conservation Units



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Figure 4. Map of Priority Management Units for mussel conservation (see Table 3 for detailed species lists by unit). Areas in gray with no rank number are additional units that harbor several species, but did not rank in the top ten. These areas do not have any additional species that are not included in at least one other priority management unit.

Bivalve Priority Conservation Subunits within Priority Management Units

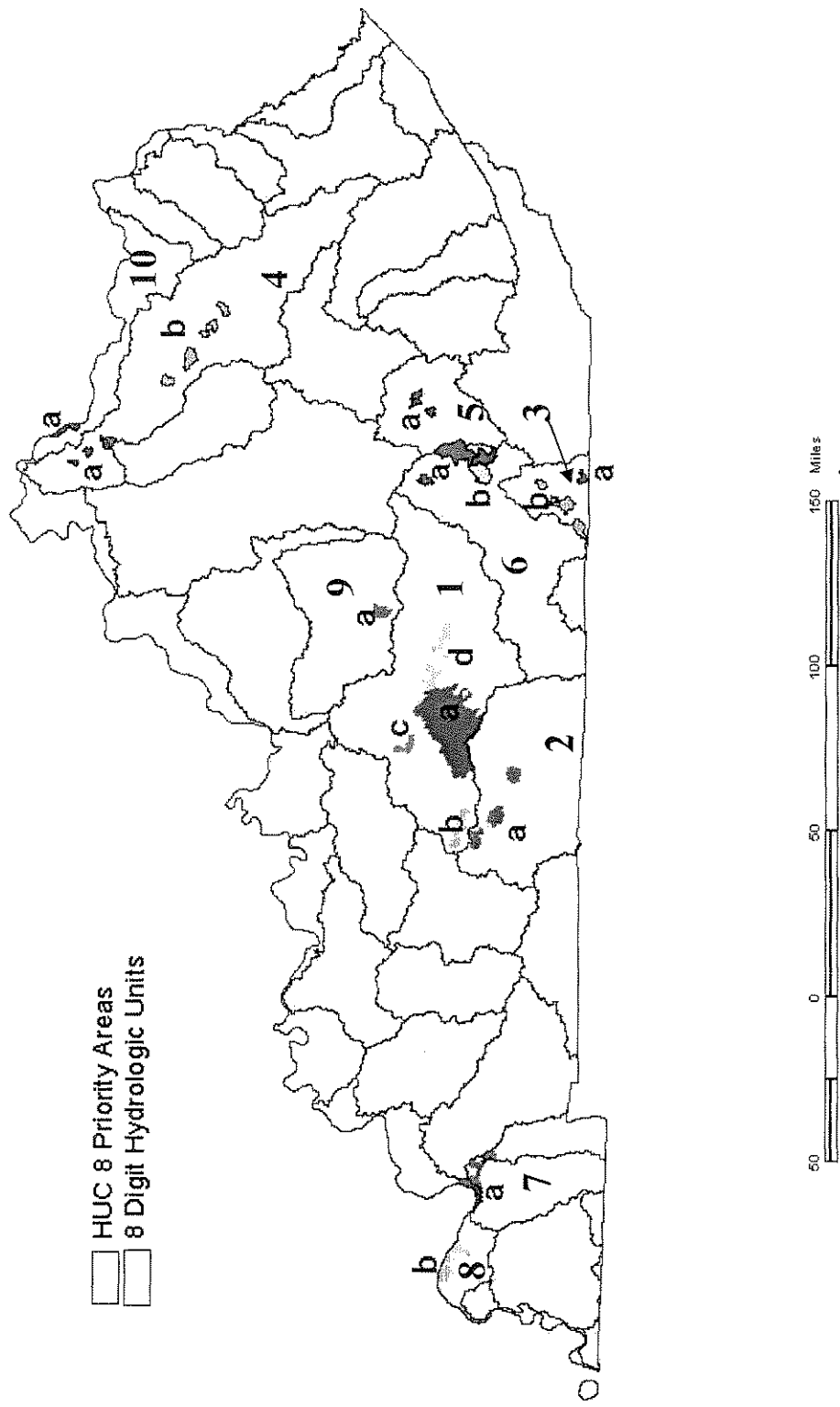


Figure 5. Map of Priority Management Subunits (HUC 14) ranked (a,b,c,d) within each larger hydrologic unit (HUC 8) for mussel conservation (see Table 3 for a list of species by each larger unit).

Table 2. Examples of mussel augmentation, expansion, and reintroduction opportunities in Kentucky (see Table 3 for more species and areas).

Site	Reference	# Species Present	# FE Species	Rare species
Cumberland River (Upper)				
Big South Fork	Biggins and Bakaletz (2002)	25	5	<i>A. atropurpurea</i> , <i>P. fabula</i> , <i>E. walkeri</i> , <i>E. brevidens</i> , <i>E. capsaeformis</i> , <i>V. trabilis</i> , <i>P. subtentum</i>
Buck Creek	Hagman and Schuster (1999)	29	4	<i>P. fabula</i> , <i>E. capsaeformis</i> <i>E. brevidens</i> , <i>V. trabilis</i> , <i>P. subtentum</i>
Horse Lick Creek	Layzer et al. (1996)	18	2	<i>P. fabula</i> , <i>V. trabilis</i> , <i>E. capsaeformis</i> , <i>E. brevidens</i> , <i>P. subtentum</i>
Marsh Creek	Cicerello (1995)	7	1	<i>A. atropurpurea</i>
Rock Creek	Cicerello (1996)	5	1	<i>A. atropurpurea</i>
Rockcastle River	Cicerello (1994), Thompson (1978)	26	3	<i>E. capsaeformis</i> <i>E. brevidens</i> , <i>V. trabilis</i> , <i>P. fabula</i> , <i>P. subtentum</i>
Sinking Creek	Personal collections	8	2	<i>A. atropurpurea</i> , <i>V. trabilis</i> , <i>P. fabula</i>
Cumberland River (Lower)	Cicerello et al. 1991	70	7	<i>L. abrupta</i> , <i>P. capax</i> , <i>O. retusa</i> , <i>P. fabula</i> , <i>P. cooperianus</i> , <i>P. clava</i> , <i>C. stegaria</i>
Red River	Starnes and Bogan 1988	22	2	<i>E. florentina</i> , <i>E. walkeri</i> , <i>P. fabula</i>
Licking River (Lower and Middle Sections)	Cicerello et al. 1991	53	5	<i>C. stegaria</i> , <i>E. torulosa rangiana</i> , <i>P. clava</i> , <i>P. plenum</i> , <i>V. fabilis</i> , <i>L. abrupta</i>

Site	Reference	# Species Present	# FE Species	Rare species
Ohio River (mainstem)		?	14	<i>L. abrupta</i> , <i>P. capax</i> , <i>O. retusa</i> , <i>P. cooperianus</i> , <i>P. clava</i> , <i>P. plenum</i> , <i>V. fabilis</i> <i>C. stegaria</i> , <i>P. cicatricosus</i> , <i>D. dromus</i> , <i>P. capax</i> , <i>C. monodonta</i> , <i>P. cyphus</i> , <i>V. fabilis</i>
Mississippi River		?	4	<i>P. capax</i> , <i>C. monodonta</i> , <i>P. cyphus</i> , <i>L. abrupta</i>
Green River Upper Green & Barren	Cicerello et al. 1991	66	12	<i>C. stegaria</i> , <i>E. obliquata</i> , <i>E. torulosa</i> <i>rangiana</i> , <i>H. lata</i> , <i>L. abrupta</i> , <i>L. leptodon</i> , <i>O. retusa</i> , <i>P. cooperianus</i> , <i>P. clava</i> , <i>P. plenum</i> , <i>P. capax</i> , <i>V. fabilis</i>
Lower Green	Cicerello et al. 1991	60	7	<i>C. stegaria</i> , <i>E. obliquata</i> , <i>E. torulosa</i> <i>rangiana</i> , <i>O. retusa</i> , <i>P. cooperianus</i> , <i>P. plenum</i> , <i>P. capax</i> , <i>L. abrupta</i>
Salt River				
Rolling Fork	Akers and Schuster 2000	33	1	<i>C. stegaria</i> , <i>E. triquetra</i>
Tennessee River				
Lower TN below KY Dam	Cicerello et al. 1991	55	5	<i>C. stegaria</i> , <i>L. abrupta</i> , <i>O. retusa</i> , <i>P. cooperianus</i> , <i>P. clava</i> , <i>P. plenum</i> , <i>D. dromus</i> , <i>P. cicatricosus</i> , <i>C. monodonta</i>
Kentucky River				
Red River	Cicerello (1997)	23	0	<i>E. triquetra</i>
Red Bird River	Cicerello (1996)	20	0	<i>E. triquetra</i>

Table 3. List of freshwater mussels in Kentucky and presence in Priority Management Units for imperiled species. Bold numbers represent historic data (pre 1984).

	Priority Rank	Priority Rank										On STWG imperiled list	Priority areas (post 1983) STWG* only	Priority Areas present (all records)
		1	2	3	4	5	6	7	8	9	10			
		Upper Green River	Lower Barren River	S.F. Cumberland	Licking River	Rockcastle River	Upper Cumberland River	Lower Ohio River	Lower Tennessee River	Rolling Fork (Salt River)	Upper Ohio River			
<i>Actinonaias ligamentina</i>	mucket	1	1	1	1	1	1			1	1	n	na	8
<i>Actinonaias pectorosa</i>	pheasantshell			1	1	1	1					n	na	4
<i>Alasmidonta atropurpurea</i>	Cumberland elktoe			1		1	1					y	2	3
<i>Alasmidonta marginata</i>	elktoe	1	1	1	1	1	1		1		y	5	7	
<i>Alasmidonta viridis</i>	slippershell mussel	1	1	1	1	1	1		1		y	7	7	
<i>Amblema plicata</i>	threeridge	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Anodonta suborbiculata</i>	flat floater		1							1		n	na	2
<i>Anodontoides denigratus</i>	Cumberland papershell					1						y	1	1
<i>Anodontoides ferussacianus</i>	cylindrical papershell		1		1							n	na	2
<i>Arcidens confragosus</i>	rockpocketbook	1	1						1			n	na	3
<i>Corbicula fluminea</i>	Asian clam	1	1	1	1	1	1		1	1	1	n	na	9
<i>Cumberlandia monodonta</i>	spectaclecase	1		1			1		1			y	2	4
<i>Cyclonaias tuberculata</i>	purple wartyback	1	1	1	1	1	1		1	1	1	n	na	9
<i>Cyprogenia stegaria</i>	fanshell	1	1		1		1		1	1	1	y	4	7
<i>Dreissena polymorpha</i>	zebra mussel								1			n	na	1
<i>Dromus dromas</i>	dromedary pearlymussel						1					y	0	1
<i>Ellipsaria lineolata</i>	butterfly	1	1		1		1		1		1	y	6	6
<i>Elliptio crassidens</i>	elephantear	1	1		1	1		1	1		1	y	6	7
<i>Elliptio dilatata</i>	spike	1	1	1	1	1	1		1	1	1	n	na	9
<i>Epioblasma brevidens</i>	Cumberlandian combshell			1		1	1					y	2	3
<i>Epioblasma capsaeformis</i>	oyster mussel			1		1	1					y	2	3
<i>Epioblasma f. walkeri</i>	tan riffleshell			1			1					y	1	2
<i>Epioblasma o. obliquata</i>	catspaw	1			1		1					y	1	3
<i>Epioblasma t. rangiana</i>	Northern riffleshell	1	1		1					1		y	3	4
<i>Epioblasma t. torulosa</i>	Tubeled blossom	1			1							n	na	2
<i>Epioblasma triquetra</i>	snuffbox	1	1	1	1		1			1	1	y	7	7
<i>Fusconaia ebena</i>	ebonyshell	1	1				1	1	1		1	n	na	6
<i>Fusconaia flava</i>	Wabash pigtoe	1	1		1	1	1	1	1	1	1	n	na	9
<i>Fusconaia s. subrotunda</i>	longsolid	1	1	1	1	1	1		1	1	1	y	6	9
<i>Hemistena lata</i>	cracking pearlymussel	1										y	0	1

Table 3. List of freshwater mussels in Kentucky and presence in Priority Management Units for imperiled species. Bold numbers represent historic data (pre 1984).

	Priority Rank	1	2	3	4	5	6	7	8	9	10			
		Upper Green River	Lower Barren River	S.F. Cumberland	Licking River	Rockcastle River	Upper Cumberland River	Lower Ohio River	Lower Tennessee River	Rolling Fork (Salt River)	Upper Ohio River	On STWG imperiled list	Priority areas (post 1983) STWG only	Priority Areas present (all records)
<i>Lampsilis abrupta</i>	pink mucket	1	1		1		1	1	1		1	y	6	7
<i>Lampsilis cardium</i>	plain pocketbook	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Lampsilis fasciola</i>	wavyrayed lampmussel	1	1	1	1	1	1			1	1	n	na	8
<i>Lampsilis ovata</i>	pocketbook	1	1	1	1	1	1	1	1	1	1	y	8	10
<i>Lampsilis siliquoidea</i>	fatmucket	1	1		1		1			1	1	n	na	6
<i>Lampsilis teres</i>	yellow sandshell	1	1		1			1	1	1		n	na	6
<i>Lasmigona complanata</i>	white heelsplitter	1	1		1			1	1	1		n	na	6
<i>Lasmigona costata</i>	flutedshell	1	1	1	1	1	1			1		n	na	7
<i>Leptodea fragilis</i>	fragile papershell	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Leptodea leptodon</i>	scaleshell	1										y	0	1
<i>Ligumia recta</i>	black sandshell	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Medionidus conradicus</i>	Cumberland moccasinshell			1		1	1					y	3	3
<i>Megaloniais nervosa</i>	washboard	1	1		1		1	1	1	1	1	n	na	8
<i>Obliquaria reflexa</i>	threehorn wartyback	1	1		1		1	1	1	1	1	n	na	8
<i>Obovaria olivaria</i>	hickorynut		1					1	1			n	na	3
<i>Obovaria retusa</i>	ring pink	1	1				1	1	1		1	y	5	6
<i>Obovaria subrotunda</i>	round hickorynut	1	1	1	1	1	1			1		y	6	7
<i>Pegias fabula</i>	littlewing pearlymussel			1		1	1					y	3	3
<i>Plectomerus dombeyanus</i>	bankclimber								1			n	na	1
<i>Plethobasus cooperianus</i>	orange-foot pimpleback	1					1	1	1		1	y	3	5
<i>Plethobasus cyphus</i>	sheepnose	1	1		1		1	1	1		1	y	6	7
<i>Pleurobema clava</i>	clubshell	1	1		1				1	1		y	3	5
<i>Pleurobema cordatum</i>	Ohio pigtoe	1	1		1		1	1	1		1	n	na	7
<i>Pleurobema oviforme</i>	Tennessee clubshell			1		1	1					y	3	3
<i>Pleurobema plenum</i>	rough pigtoe	1	1		1		1				1	y	3	5
<i>Pleurobema rubrum</i>	pyramid pigtoe	1	1	1	1		1	1	1	1	1	y	5	9
<i>Pleurobema sintoxia</i>	round pigtoe	1		1		1				1		n	na	4
<i>Potamilus alatus</i>	pink heelsplitter	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Potamilus capax</i>	fat pocketbook							1				y	1	1
<i>Potamilus ohiensis</i>	pink papershell	1	1		1		1	1				n	na	5
<i>Potamilus purpuratus</i>	bleufer							1				y	1	1

Table 3 (cont). List of freshwater mussels in Kentucky and presence in Priority Management Units for imperiled species. Bold numbers represent historic data (pre 1984).

	Priority Rank	1	2	3	4	5	6	7	8	9	10			
		Upper Green River	Lower Barren River	S.F. Cumberland	Licking River	Rockcastle River	Upper Cumberland River	Lower Ohio River	Lower Tennessee River	Rolling Fork (Salt River)	Upper Ohio River	On STWG imperiled list	Priority areas (post 1983) STWG only	Priority Areas present (all records)
<i>Ptychobranhus fasciolaris</i>	kidneyshell	1	1	1	1	1	1		1	1	1	n	na	9
<i>Ptychobranhus subtentum</i>	fluted kidneyshell			1		1	1					y	3	3
<i>Pyganodon grandis</i>	giant floater	1	1	1	1	1		1	1	1	1	n	na	9
<i>Quadrula c. cylindrica</i>	rabbitsfoot	1	1	1	1	1	1	1	1		1	y	4	9
<i>Quadrula metanevra</i>	monkeyface	1	1		1		1	1	1		1	n	na	7
<i>Quadrula nodulata</i>	wartyback				1			1	1	1	1	n	na	5
<i>Quadrula pustulosa</i>	pimpleback	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Quadrula quadrula</i>	mapleleaf	1	1		1			1	1	1	1	n	na	7
<i>Simpsonaias ambigua</i>	salamander mussel	1			1					1	1	y	3	4
<i>Strophitus undulatus</i>	creeper	1	1	1	1	1	1			1	1	n	na	8
<i>Toxolasma lividus</i>	purple lilliput	1	1	1	1	1	1					y	5	6
<i>Toxolasma parvus</i>	lilliput			1	1					1		n	na	3
<i>Toxolasma texasiensis</i>	Texas lilliput								1			y	1	1
<i>Tritogonia verrucosa</i>	pistolgrip	1	1	1	1	1	1	1	1	1	1	n	na	10
<i>Truncilla donaciformis</i>	fawnsfoot	1	1		1	1		1	1	1		n	na	7
<i>Truncilla truncata</i>	deertoe	1	1		1	1	1	1	1	1		n	na	8
<i>Utterbackia imbecillis</i>	paper pondshell	1			1		1		1	1		n	na	5
<i>Villosa iris</i>	rainbow	1	1	1	1	1	1				1	n	na	7
<i>Villosa lienosa</i>	little spectaclecase	1	1	1	1	1	1		1	1	1	y	6	9
<i>Villosa ortmanni</i>	Kentucky creekshell	1	1									y	2	2
<i>Villosa taeniata</i>	painted creekshell			1		1	1					n	na	3
<i>Villosa trabalis</i>	Cumberland bean			1		1	1					y	3	3
<i>Villosa vanuxemensis</i>	mountain creekshell			1			1					y	0	2
	STWG	24	20	20	23	22	25	12	17	16	15			
	not on STWG list	34	34	21	35	23	28	22	29	30	25			
	Total Mussels	58	54	41	58	45	53	34	46	46	40			
	% of total mussels in KY	69	64	49	69	54	63	40	55	55	48			
	SWG % mussels in HUC	41	37	49	40	49	47	35	37	35	38			
	SWG % of KY Mussels	29	24	24	27	26	30	14	20	19	18			

*STWG=state and tribal wildlife grant list of priority species for Kentucky

Table 4. List of additional freshwater mussels found in Kentucky but absent from Priority Management Units. Species on the STWG list are noted.

Additional species found in Kentucky (historic records only (pre 1984))		
Scientific Name	Common Name	On STWG
<i>Epioblasma haysiana</i>	acornshell	n
<i>Epioblasma biemarginata</i>	angled riffleshell	n
<i>Epioblasma phillipsii</i>	Cincinnati riffleshell	n
<i>Lasmigona compressa*</i>	creek heelsplitter	y
<i>Epioblasma stewardsonii</i>	Cumberland leafshell	n
<i>Epioblasma lewisii</i>	forkshell	n
<i>Lasmigona subviridis</i>	green floater	y
<i>Quadrula nobilis</i>	gulf mapleleaf	n
<i>Epioblasma flexuosa</i>	leafshell	n
<i>Unio merus tetralasmus</i>	pondhorn	n
<i>Ligumia subrostrata</i>	pondmussel	n
<i>Villosa fabalis</i>	rayed bean	y
<i>Quadrula tuberosa</i>	rough rockshell	n
<i>Epioblasma personata</i>	round combshell	n
<i>Lexingtonia dolabelloides</i>	slabside pearly mussel	y
<i>Epioblasma arcaeformis</i>	sugarspoon	n
<i>Epioblasma propinqua</i>	Tennessee riffleshell	n
<i>Epioblasma sampsonii</i>	Wabash riffleshell	n
<i>Epioblasma o. perobliqua</i>	white catspaw	n
<i>Plethobasus cicatricosus</i>	white wartyback	n
<i>Quadrula fragosa</i>	winged mapleleaf	y
<i>Epioblasma f. florentina</i>	yellow blossom	n

*not in priority area

Table 5 . Example of a site evaluation for augmentation, expansion, and reintroduction.

Site Description: (includes specific dimensions, substrate types, water quality, etc.)

Watershed Conservation Practices in Place (describe in detail):

Number of Collections at Site:

Species present at site (historic and recent): Mussels and hosts

1	11	21	31	41	51
2	12	22	32	42	52
3	13	23	33	43	53
4	14	24	34	44	54
5	15	25	35	45	55
6	16	26	36	46	56
7	17	27	37	47	57
8	18	28	38	48	58
9	19	29	39	49	59
10	20	30	40	50	60

Example of Ranking Criteria

Conservation Option	Site Selection				
	# species at site	# endangered Species	# threatened species	# KSNPC E& T species	# imperiled species (SWG)
augmentation					
expansion, or reintroduction					

Rank	Presence in	multiple	host fish	fish pop
(> 40 species=5)	Priority	recruit.	present	condit.
30-40=4, 20-30=3	Area	present	for most	
10-20=2, < 10=1		good=5 none=0	species	healthily=5 poor=1

water quality	Access to site	Grand Total	Rank
adeq.	5=good access		
good=5 poor=1	5= good prot. 1=no prot.		

Table 6. Rank of Kentucky mussels for propagation purposes. A high rank implies that a species can be cultured with a higher probability of success, based on current information.

USFWS Status	KSNPC Status	Global Rank	State Rank	Weight*	Scientific Name	Culture Rank Test Scores					Host refer. recent				
						Species Selection (A-I)	Metapop viable	Juv present	At risk of extinc	life history known		Host fish known	handling easy=5	Host sensit. easy=5	Total score
						5=high	many fem=5	high=5	high=20	5	high=5, low=1	unk=5	difficult=1	unk=5	Sub score
LE,XN	E	G1	S1	80	<i>Villosa trabalis</i>	2	2	2	18	5	4	4	3	40	R
LE	E	G1	S1	80	<i>Cyprogenia stegaria</i>	3	3	3	15	4	4	4	3	39	R
LE	E	G2	S1	40	<i>Lampsilis abrupta</i>	1	1	1	18	4	5	4	5	39	R
C	H	G2	SH		<i>Lexingtonia dolabelloides</i>	1	1	1	20	3	4	5	3	38	R
N	N	G3G4	S4	8	<i>Melitonius conradicus</i>	3	3	2	15	4	4	4	3	38	R
LE,XN	X	G1	SX		<i>Dromus dromas</i>	1	1	1	20	3	4	4	4	38	R
LE	E	G2T2	S1	40	<i>Epioblasma torulosa rangiana</i>	1	1	1	20	3	4	3	3	36	R
LE,XN	E	G1	S1	80	<i>Epioblasma cupsaeformis</i>	1	1	1	20	4	4	1	4	36	R
N	N	G5	S4S5	2	<i>Actinonaias ligamentina</i>	5	5	5	1	5	5	5	5	36	R
LE	E	G1	S1	80	<i>Potamilus capax</i>	1	1	1	18	4	4	4	2	35	R
LE	E	G1	S1	80	<i>Pegias fabula</i>	1	1	1	20	4	4	1	3	35	R
N	S	G3	S3	12	<i>Epioblasma triquetra</i>	2	1	1	18	4	4	2	3	35	R
LE,XN	E	G1	S1	80	<i>Epioblasma brevidens</i>	2	1	1	18	4	4	1	4	35	R
LE,XN	X	G1	SX		<i>Quadrula fragosa</i>	1	1	1	20	3	3	1	5	35	R
N	E	G3	S1	20	<i>Pleurobema oxiforme</i>	2	1	1	18	3	4	1	5	35	R
N	N	G4	S4S5	4	<i>Lampsilis fasciola</i>	5	5	5	1	5	5	4	5	35	R
N	N	G5	S4S5	2	<i>Lampsilis cardium</i>	5	5	5	1	5	5	4	5	35	R
N	N	G5	S4S5	2	<i>Lampsilis silquidea</i>	5	5	5	1	5	5	4	5	35	R
N	N	G5	S4S5	2	<i>Utterbackia imbecillis</i>	5	5	5	1	5	5	4	5	35	R
LE,XN	E	G2	S1	40	<i>Pleurobema elava</i>	1	1	1	20	3	4	1	3	34	R
LE	E	G1T1	SX		<i>Epioblasma florentina walkeri</i>	1	1	1	18	4	4	1	4	34	R
N	N	G4	S4S5	4	<i>Obovata subrotunda</i>	2	1	1	15	4	4	3	4	34	R
N	T	G4	S2	8	<i>Villosa vanuxemensis</i>	1	1	1	15	4	4	4	4	34	R
N	N	G5	S4S5	2	<i>Elliptio dilatata</i>	5	5	5	1	5	4	4	5	34	R
N	N	G5	S4S5	2	<i>Villosa iris</i>	5	5	5	1	5	4	4	5	34	R
N	N	G3G4	S4	8	<i>Villosa taeniata</i>	5	5	5	1	5	4	4	4	33	R
N	N	G5	S4S5	2	<i>Amblyema plicata</i>	5	5	5	1	4	5	3	5	33	R
N	E	G5	S1	5	<i>Lasmitigona compressa</i>	1	1	1	20	1	2	2	5	33	R
N	N	G5	S4S5	2	<i>Potamilus alatus</i>	5	5	5	1	4	4	4	5	33	R
N	N	G5	S4S5	2	<i>Pyganodon grandis</i>	5	5	5	1	5	4	4	3	32	R

Table 6 (cont.). Rank of Kentucky mussels for propagation purposes. A high rank implies that a species can be cultured with a higher probability of success.

USFWS Status	KSNPC Status	Global Rank	State Rank	Weight*	Scientific Name	Culture Rank Test Scores										Host refer.
						Species Selection (A-I)		Host fish		handling		Host		Total score		
						Extant Pop Present	Metapop viable	Juv present	At risk of extinc	life history known	fish known	easy=5	sensit. easy=5		Sub score	
5=high	many fem=5	high=5	high=20	5	high=5, low=1	unk=5	diff=1	score	recent							
N	N	G5	S4S5	2	<i>Megalomias nervosa</i>	5	5	4	1	5	4	4	4	32	R	
N	E	G2	S1	40	<i>Toxolasma lividata</i>	2	1	1	15	3	4	1	5	32	R	
N	N	G4	S4S5	4	<i>Quadrula nodulata</i>	3	3	3	10	3	4	1	5	32	O	
N	E	G4	S1	10	<i>Toxolasma texastensis</i>	1	1	1	15	3	3	3	5	32	R	
N	N	G5	S4S5	2	<i>Cyclonaias tuberculata</i>	5	5	4	1	5	4	3	5	32	R	
N	N	G5	S4S5	2	<i>Lasmigona costata</i>	5	5	5	1	4	5	2	5	32	R	
N	N	G5	S4S5	2	<i>Quadrula pustulosa</i>	5	5	5	3	4	4	1	5	32	R	
N	S	G3	S3	12	<i>Plethobasus cyphus</i>	2	2	2	15	3	2	2	3	31	O	
LE,XN	X	G2TX	SX	1	<i>Epioblasma torulosa torulosa</i>	1	1	1	20	3	0	5	0	31	U	
N	N	G5	S4S5	2	<i>Strophitus undulatus</i>	5	5	5	1	5	4	4	2	31	R	
N	N	G5	S4S5	2	<i>Oblitquaria reflexa</i>	5	4	4	1	4	4	4	5	31	R	
LE	E	G1G2	S1	80	<i>Alasmidonta atropurpurea</i>	1	1	1	18	3	4	1	1	30	R	
LE	E	G1G1	S1	80	<i>Epioblasma obliquata obliquata</i>	1	1	1	20	2	0	5	0	30	U	
LE	X	G1G1	SX	1	<i>Epioblasma obliquata perobliqua</i>	1	1	1	20	2	0	5	0	30	U	
N	X	GX	SX	1	<i>Epioblasma haystana</i>	1	1	1	20	1	1	5	0	30	U	
N	N	G5	S4S5	2	<i>Fusconaiia flava</i>	5	5	5	1	5	4	1	4	30	O	
N	N	G5	S4S5	2	<i>Leptodea fragilis</i>	5	5	5	1	3	4	4	2	29	R	
LE,XN	X	GX	SX	1	<i>Epioblasma phillipsii</i>	1	1	1	20	1	0	5	0	29	U	
LE	X	G1	SX	1	<i>Leptodea leptodon</i>	1	1	1	20	1	0	5	0	29	U	
LE	E	G1	S1	80	<i>Obovaria retusa</i>	1	1	1	20	1	0	5	0	29	U	
LE	X	G1	SX	1	<i>Plethobasus cicatricosus</i>	1	1	1	20	1	0	5	0	29	U	
LE	E	G1	S1	80	<i>Plethobasus cooperianus</i>	1	1	1	20	1	0	5	0	29	U	
N	E	G1G2	S1	80	<i>Villosa fabalis</i>	1	1	1	20	3	0	3	0	29	U	
C	E	G2G3	S1	40	<i>Pychobranchus subtentum</i>	2	2	2	10	3	4	3	3	29	R	
N	N	G4G5	S4S5	4	<i>Fusconaiia ebena</i>	5	5	5	1	5	4	1	3	29	O	
N	X	GX	SX	1	<i>Epioblasma arcaeformis</i>	1	1	1	20	1	0	5	0	29	U	
N	X	GX	SX	1	<i>Epioblasma biemarginata</i>	1	1	1	20	1	0	5	0	29	U	
N	X	GX	SX	1	<i>Epioblasma flexuosa</i>	1	1	1	20	1	0	5	0	29	U	
LE,XN	X	G1GX	SX	1	<i>Epioblasma florentina florentina</i>	1	1	1	20	1	0	5	0	29	U	
N	X	GX	SX	1	<i>Epioblasma lewisii</i>	1	1	1	20	1	0	5	0	29	U	
N	X	GX	SX	1	<i>Epioblasma personata</i>	1	1	1	20	1	0	5	0	29	U	

Table 6 (cont.). Rank of Kentucky mussels for propagation purposes. A high rank implies that a species can be cultured with a higher probability of success.

USFWS Status	KSNPC Status	Global Rank	State Rank	Weight*	Scientific Name	Culture Rank Test Scores										Host refer. old recent	
						Species Selection (A-I)		Extant Pop Present	Metapop viable many fem=5	Juv present high=5	At risk of extinc high=20	life history known 5	Host fish known high=5, low=1	handling easy=5 difficult=1 unk=5	Host sensit. easy=5 diff=1		Total Sub score
						Present	5=high										
N	X	GX	SX		<i>Epioblasma propinqua</i>	1	1	1	20	1	0	5	0	29	U		
N	X	GX	SX		<i>Epioblasma sampsonii</i>	1	1	1	20	1	0	5	0	29	U		
N	X	GX	SX		<i>Epioblasma stewartsonii</i>	1	1	1	20	1	0	5	0	29	U		
N	X	GX	SX		<i>Quadrula tuberosa</i>	1	1	1	20	1	0	5	0	29	U		
N	T	G3T3	S2	16	<i>Quadrula cylindrica cylindrica</i>	2	2	2	10	3	4	1	5	29	R		
N	N	G4	S4S5	4	<i>Actinonates pectorosa</i>	5	3	3	1	4	5	3	5	29	R		
N	E	G5	S1	5	<i>Lampsilis ovata</i>	3	5	5	1	3	3	4	5	29	O		
N	N	G5	S4S5	2	<i>Lampsilis teres</i>	4	4	4	1	3	4	4	5	29	O		
N	T	G3	S2S3	16	<i>Simpsoniata ambigua</i>	2	1	1	15	5	2	1	1	28	O		
N	N	G4	S4S5	4	<i>Ellipsaria lineolata</i>	5	4	3	5	3	4	3	1	28	R		
N	N	G4G5	S4S5	4	<i>Pychobranchus fasciolaris</i>	5	5	5	1	4	4	3	1	28	R		
N	N	G4	S4S5	4	<i>Pleurobema sintoxia</i>	5	3	3	5	3	3	1	5	28	R		
N	N	G5	S4S5	2	<i>Potamilus ohioensis</i>	2	4	4	4	3	4	4	2	27	R		
N	N	G5	S4S5	2	<i>Truncilla donaciformis</i>	3	2	2	8	4	4	2	2	27	O		
LE, XN	X	G1	SX		<i>Hemistena lata</i>	1	1	1	20	1	2	1	0	27	R		
N	E	G3	S1	20	<i>Lasmigona subviridis</i>	1	1	1	18	4	0	2	0	27	U		
N	N	G4G5	S4S5	4	<i>Alasmidonta viridis</i>	5	4	4	1	4	4	1	4	27	R		
N	N	G4	S4S5	4	<i>Tritogonia verrucosa</i>	5	5	5	1	4	2	1	4	27	R		
N	N	G5	S4S5	2	<i>Quadrula quadrula</i>	5	5	5	1	4	1	1	5	27	O		
N	N	G5	S4S5	2	<i>Toxolasma parvus</i>	3	3	3	2	4	4	3	5	27	R		
N	N	G5	S4S5	2	<i>Elliptio crassidens</i>	4	4	3	5	3	4	3	1	26	O		
N	E	G1	S1	80	<i>Anodontooides demigratus</i>	3	3	3	4	3	2	5	3	26	?		
N	N	G4	S4S5	4	<i>Arcidens confragosus</i>	4	4	4	1	4	3	3	3	26	O		
N	N	G3	S4S5	8	<i>Pleurobema cordatum</i>	5	4	4	4	3	4	1	4	26	R		
N	N	G5	S4S5	2	<i>Ligumia recta</i>	3	2	1	5	4	4	2	5	26	R		
N	E	G5	S1	5	<i>Potamilus purpuratus</i>	3	4	4	2	3	4	4	1	26	R		
LE	E	G1	S1	80	<i>Pleurobema plenum</i>	2	1	1	18	2	0	1	0	25	U		
N	N	G4	S4S5	4	<i>Quadrula metonevra</i>	5	5	5	1	4	4	1	0	25	O		
N	N	G5	S4S5	2	<i>Anodontooides ferussacianus</i>	3	3	3	1	3	4	5	3	25	?		
N	N	G5	S4S5	2	<i>Lasmigona complanata</i>	5	4	3	1	3	4	2	3	25	R		

Table 6 (cont.). Rank of Kentucky mussels for propagation purposes. A high rank implies that a species can be cultured with a higher probability of success.

USFWS Status	KSNPC Status	Global Rank	State Rank	Weight*	Scientific Name	Culture Rank Test Scores											
						Species Selection (A-1)					Life History					Host	
						Extant Pop Present	Metapop viable many fem=5	Juv present high=5	At risk of extinc high=20	life history known	Host fish fish known	handling easy=5 difficult=1 unk=5	Host sensit. easy=5 diff=1	Total Sub score	Host refer. old recent		
N	S	G5	S3S4	3	<i>Villosa lianosa</i>	3	3	3	8	3	0	5	0	25	U		
N	E	G2G3	S1	40	<i>Cumberlandia monodonta</i>	1	1	1	15	1	0	4	1	24	R-P		
N	N	G5	S4S5	2	<i>Truncilla truncata</i>	3	2	2	8	4	2	2	1	24	O		
N	E	G2	S1	40	<i>Pleurobema rubrum</i>	2	1	1	18	1	0	1	0	24	U		
N	T	G2	S2	32	<i>Villosa ortmanni</i>	2	3	3	10	1	0	5	0	24	U		
N	N	G4	S4S5	4	<i>Obovaria olivaria</i>	2	2	2	5	4	3	3	3	24	R		
N	N	G4	S4S5	4	<i>Unio merus tetralasmus</i>	2	2	2	4	3	1	5	5	24	R		
N	N	G4G5	S4S5	4	<i>Ligumia subrostrata</i>	1	1	1	5	1	4	5	5	23	R		
N	N	G5	S4S5	2	<i>Anodonta suborbiculata</i>	5	3	3	1	4	0	5	0	21	U		
N	S	G3T3	S3	12	<i>Fusconia subrotunda subrotunda</i>	3	2	2	10	1	0	1	0	19	U		
N	T	G4	S2	8	<i>Alasmodonta marginata</i>	2	2	1	5	3	3	1	1	18	O		
N	N	G4	S?		<i>Plectomerus dombeyanus</i>	1	1	1	5	3	0	5	0	16	U		
N	N	G5	S4	2	<i>Quadrula nobilis</i>	2	4	4	1	3	0	1	0	15	U		

*Weight is determined by the following matrix

	S1	S2	S3	S4	S5
G1	80	64	48	32	16
G2	60	48	36	24	12
G3	40	32	24	16	8
G4	20	16	12	8	4
G5	5	4	3	2	1

Facilities for Propagation

KDFWR has developed facilities for mussel propagation at the Forks of Elkhorn Transportation Section (an old fish hatchery) and at Minor Clark National Fish Hatchery (in coordination with Tennessee Technological University). KDFWR is also working cooperatively with Kentucky State University, Eastern Kentucky University, and the Wolf Creek National Fish Hatchery. The primary facility is the Center for Mollusk Conservation (see Appendix), established in 2002 as a multiphase facility capable of holding adults in semi-natural conditions, culture of juvenile mussels, and growout of juveniles to a larger, stockable size. In 2002-2003, biologists have successfully reared several species and have shown significant growth of many of these species. Survival has been good at the facility for the last year and many mussels have displayed normal brooding cycles (compared to natural periods). KDFWR has the ability to expand its capability to work with additional species and is seeking funds to work with endangered species found in KY's waters. It may be necessary to work with a surrogate species to develop techniques if that genus/species has not been cultured previously. Benefits of a mussel propagation facility include enhanced ability to augment, restore, and recover endangered mussel populations. Information on mussel resources, including distribution, population status, recruitment, life history, culture and growout methods, holding facilities for critically rare animals will be evaluated and examined for improving awareness of the resource needs and recovery potential. Increasing public awareness (education and outreach) about endangered and imperiled aquatic fauna and threats and mitigation practices will make citizens aware of conservation issues and needs. The project will promote a cooperative effort among intra and inter state organizations and state and federal wildlife agencies.

This Plan is a working document that is subject to modification based on results of current and future research and recovery activities involving mollusk propagation, augmentation, or reintroduction. Recovery Partners are encouraged to provide comments and suggestions to Monte McGregor, Kentucky Department of Fish and Wildlife Resources.

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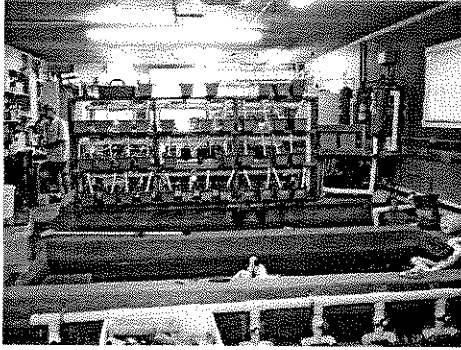
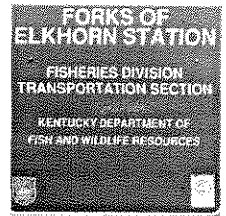
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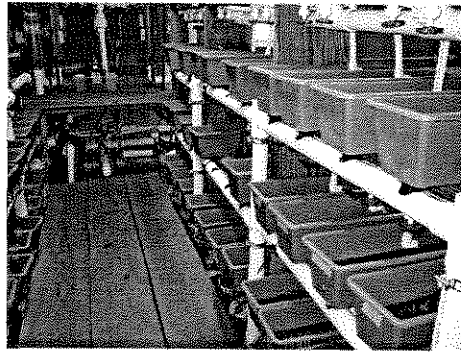
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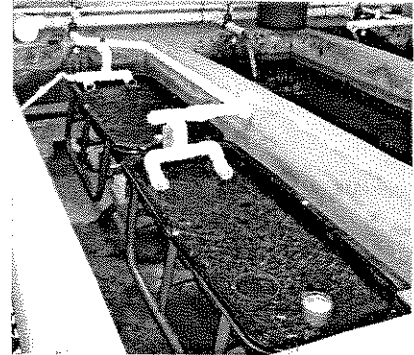
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Center for Mollusk Conservation



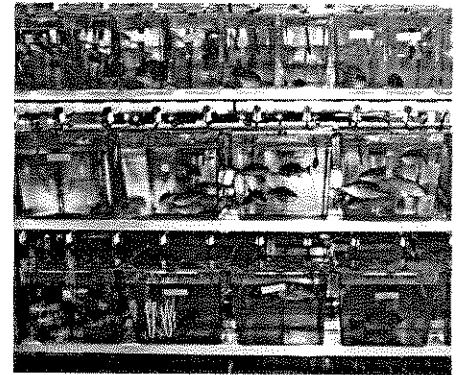
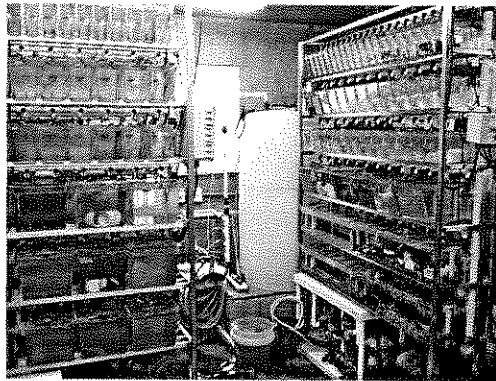
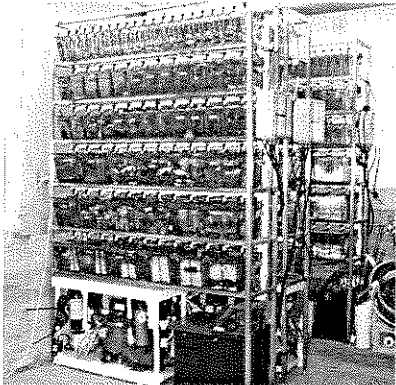
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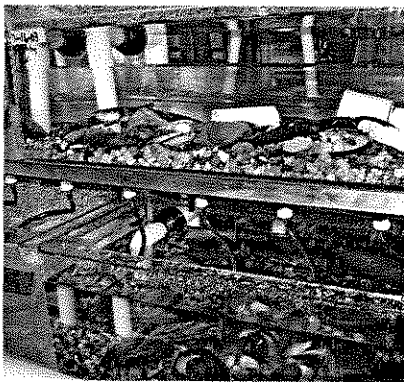
Juvenile nursery



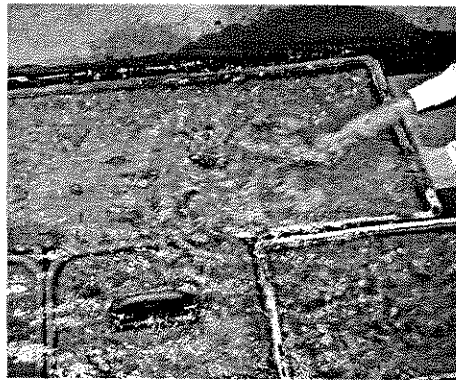
Seminatural raceways with river bottom substrata



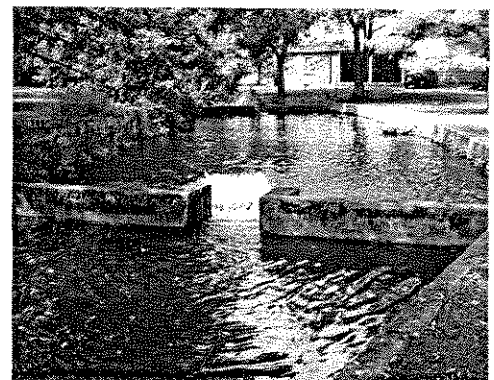
Culture tanks for infesting hosts



Fish holding tanks



Mussel tanks



Outside raceways for fish and mussels

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List of the 103 Freshwater Mussels Kentucky with author, sufamily, U.S., KSNPC, and AFS listing (Cicerello et al. 1991). ▼ found in mainstem Mississippi River							
SPECIES in Kentucky	AUTHOR	Common Name	Subfamily	Fanual group	KSNPS	AFS* status	FWS status
<i>Actinonaias ligamentina</i>	Lamarck, 1819	mucket	Lampsilinae	Mississippian	NL	CS	
<i>Actinonaias pectorosa</i>	Conrad, 1834	pheasantshell	Lampsilinae	Cumberlandian	NL	SC	
<i>Alasmidonta atropurpurea</i>	Raf., 1831	Cumberland elktoe	Anodontinae	Cumberlandian	E	E	FE
<i>Alasmidonta marginata</i>	Say, 1818	elktoe	Anodontinae	Mississippian	T	SC	
<i>Alasmidonta viridis</i>	Raf., 1820	slippershell mussel	Anodontinae	Mississippian	NL	SC	
<i>Amblema plicata plicata</i>	Say, 1817	threeridge	Ambleminae	Mississippian ▼	NL	CS	
<i>Pyganodon grandis</i>	Say, 1829	giant floater	Anodontinae	Mississippian ▼	NL	CS	
<i>Utterbackia imbecillis</i>	Say, 1829	paper pondshell	Anodontinae	Mississippian ▼	NL	CS	
<i>Anodonta suborbiculata</i>	Say, 1831	flat floater	Anodontinae	Mississippian	NL	CS	
<i>Anodontoidea ferrussacianus=denigratus</i>	I. Lea, 1834	cylindrical papershell=Cumberland papershell	Anodontinae	Mississippian	E	CS	
<i>Arcidens confragosus</i>	Say, 1829	rockpocketbook	Anodontinae	Mississippian ▼	NL	CS	
<i>Cumberlandia monodonta</i>	Say, 1829	spectaclecase	Cumberlandinae	Mississippian	E	T	
<i>Cyclonaias tuberculata</i>	Raf., 1820	purple wartyback	Pleurobeminiae	Mississippian	NL	SC	
<i>Cyprogenia stegaria</i>	Raf., 1820	fanshell	Lampsilinae	Mississippian	E	E	FE
<i>Dromus dromas</i>	I. Lea, 1834	dromedary pearlymussel	Lampsilinae	Cumberlandian	E	E	FE
<i>Ellipsaria lineolata</i>	Raf., 1820	butterfly	Lampsilinae	Mississippian	NL	SC	
<i>Elliptio crassidens</i>	Lamarck, 1819	elephantear	Pleurobeminiae	Mississippian ▼	NL	CS	
<i>Elliptio dilatata</i>	Raf., 1820	spike	Pleurobeminiae	Mississippian	NL	CS	
<i>Epioblasma arcaeiformis</i>	I. Lea, 1831	sugarspoon	Lampsilinae	Cumberlandian	NL*	E*	FE*
<i>Epioblasma biemarginata</i>	I. Lea, 1857	angled riffleshell	Lampsilinae	Cumberlandian	NL*	E*	FE*
<i>Epioblasma brevidens</i>	Lea, 1831	Cumberlandian combshell	Lampsilinae	Cumberlandian	E	E	FE
<i>Epioblasma capsaeformis</i>	Lea, 1834	oyster mussel	Lampsilinae	Cumberlandian	E	E	FE
<i>Epioblasma flexuosa</i>	Raf., 1820	leafshell	Lampsilinae	Mississippian	NL*	E*	FE*
<i>Epioblasma f. florentina</i>	I. Lea, 1857	yellow blossom	Lampsilinae	Cumberlandian	NL*	E*	FE*

<i>Epioblasma f. walkeri</i>	Wilson & Clark, 1914	tan ruffleshell	Lampsilinae	Cumberlandian	NL	E	FE
<i>Epioblasma haypsiana</i>	I. Lea, 1833	acornshell	Lampsilinae	Cumberlandian	NL*	E*	FE*
<i>Epioblasma lewisii</i>	Walker, 1910	forkshell	Lampsilinae	Cumberlandian	NL*	E*	FE*
<i>Epioblasma obliquata obliquata</i>	Raf., 1820	catspaw	Lampsilinae	Mississippian	E	E	FE
<i>Epioblasma obliquata perobliqua</i>	Comrad, 1836	white catspaw	Lampsilinae	Mississippian	NL	E	FE
<i>Epioblasma personata</i>	Say, 1829	round combshell	Lampsilinae	Mississippian	NL*	E*	FE*
<i>Epioblasma propinqua</i>	I. Lea, 1857	Tennessee ruffleshell	Lampsilinae	Mississippian	NL*	E*	FE*
<i>Epioblasma sampsonii</i>	I. Lea, 1861	Wabash ruffleshell	Lampsilinae	Mississippian	NL*	E*	FE*
<i>Epioblasma stewardsonii</i>	I. Lea, 1852	Cumberland leafshell	Lampsilinae	Cumberlandian	NL*	E*	FE*
<i>Epioblasma t. rangiana</i>	I. Lea, 1839	Northern ruffleshell	Lampsilinae	Mississippian	E	E	FE
<i>Epioblasma t. torulosa</i>	Raf., 1820	Tubeclad blossom	Lampsilinae	Mississippian	NL*	E*	FE*
<i>Epioblasma triquetra</i>	Raf., 1820	snuffbox	Lampsilinae	Mississippian	S	T	
<i>Fusconaia ebena</i>	I. Lea, 1831	ebonyshell	Ambleminae	Mississippian ▼	NL	CS	
<i>Fusconaia flava</i>	Raf., 1820	Wabash pigtoe	Ambleminae	Mississippian	NL	CS	
<i>Fusconaia subrotunda</i>	I. Lea, 1831	longsolid	Ambleminae	Mississippian	S	SC	
<i>Glebula rotundata</i>	Lamarck, 1819	round pearlshell	Lampsilinae	Mississippian	NL	CS	
<i>Hemistena lata</i>	Raf., 1820	cracking pearlymussel	Pleurobeminiae	Mississippian	NL	E	FE
<i>Lampsilis abrupta</i>	Say, 1831	pink mucket	Lampsilinae	Mississippian	E	E	FE
<i>Lampsilis cardium</i>	Raf., 1820	plain pocketbook	Lampsilinae	Mississippian	NL	SC	
<i>Lampsilis fasciola</i>	Raf., 1820	wavyrayed lampmussel	Lampsilinae	Mississippian	NL	CS	
<i>Lampsilis ovata</i>	Say, 1817	pocketbook	Lampsilinae	Mississippian	E	SC	
<i>Lampsilis siliquoidea</i>	Barnes, 1823	fatmucket	Lampsilinae	Mississippian	NL	CS	
<i>Lampsilis teres</i>	Raf., 1820	yellow sandshell	Lampsilinae	Mississippian ▼	NL	CS	
<i>Lasmigona complanata</i>	Barnes, 1823	white heelsplitter	Anodontinae	Mississippian ▼	NL	CS	
<i>Lasmigona compressa</i>	I. Lea, 1829	creek heelsplitter	Anodontinae	Mississippian	E	CS	
<i>Lasmigona costata</i>	Raf., 1820	flutedshell	Anodontinae	Mississippian	NL	CS	
<i>Lasmigona subviridis</i>	Conrad, 1835	green floater	Anodontinae	Mississippian	E	T	
<i>Leptodea fragilis</i>	Raf., 1820	fragile papershell	Lampsilinae	Mississippian ▼	NL	CS	
<i>Leptodea leptodon</i>	Raf., 1820	scaleshell	Lampsilinae	Mississippian	NL	E	FE

<i>Lexingtonia dolabelloides</i>	I. Lea, 1840	slabside pearlymussel	Ambleminae	Cumberlandian	H	T
<i>Ligumia recta</i>	Lamarck, 1819	black sandshell	Lampsilinae	Mississippian ▼	NL	SC
<i>Ligumia subrostrata</i>	Say, 1831	pondmussel	Lampsilinae	Mississippian	NL	CS
<i>Medionidius conradicus</i>	I. Lea, 1834	Cumberland moccasinshell	Lampsilinae	Cumberlandian	NL	SC
<i>Megalonaias nervosa</i>	Raf., 1820	washboard	Megalonaidinae	Mississippian ▼	NL	CS
<i>Obliquaria reflexa</i>	Raf., 1820	threehorn wartyback	Lampsilinae	Mississippian ▼	NL	CS
<i>Obovaria olivaria</i>	Raf., 1820	hickorynut	Lampsilinae	Mississippian ▼	NL	CS
<i>Obovaria retusa</i>	Lamarck, 1819	ring pink	Lampsilinae	Mississippian	E	FE
<i>Obovaria subrotunda</i>	Raf., 1820	round hickorynut	Lampsilinae	Mississippian	NL	SC
<i>Pegias fabula</i>	I. Lea, 1838	littewing pearlymussel	Anodontinae	Cumberlandian	E	FE
<i>Plectomerus dombeyanus</i>	Valenciennes, 1827	bankclimber	Ambleminae	Mississippian	NL	CS
<i>Plethobasus cicatricosus</i>	Say, 1829	white wartyback	Pleurobeminiae	Mississippian	NL	E
<i>Plethobasus cooperianus</i>	I. Lea, 1834	orange-foot pimpleback	Pleurobeminiae	Mississippian	E	FE
<i>Plethobasus cyphus</i>	Raf., 1820	sheepnose	Pleurobeminiae	Mississippian	S	T
<i>Pleurobema clava</i>	Lamarck, 1819	clubshell	Pleurobeminiae	Mississippian	E	FE
<i>Pleurobema coccineum</i>	Conrad, 1834	round pigtoe	Pleurobeminiae	Mississippian	NL	CS
<i>Pleurobema cordatum</i>	Raf., 1820	Ohio pigtoe	Pleurobeminiae	Mississippian	NL	SC
<i>Pleurobema oviforme</i>	Conrad, 1834	Tennessee clubshell	Pleurobeminiae	Cumberlandian	E	SC
<i>Pleurobema plenum</i>	I. Lea, 1840	rough pigtoe	Pleurobeminiae	Mississippian	E	FE
<i>Pleurobema rubrum</i>	I. Lea, 1840	pyramid pigtoe	Pleurobeminiae	Mississippian	E	T
<i>Potamilus alatus</i>	Say, 1817	pink heelsplitter	Lampsilinae	Mississippian ▼	NL	CS
<i>Potamilus capax</i>	Green, 1832	fat pocketbook	Lampsilinae	Mississippian	E	FE
<i>Potamilus ohioensis</i>	Raf., 1820	pink papershell	Lampsilinae	Mississippian ▼	NL	CS
<i>Potamilus purpuratus</i>	Lamarck, 1819	bleufer	Lampsilinae	Mississippian ▼	E	CS
<i>Ptychobranchus fasciolaris</i>	Raf., 1820	kidneyshell	Lampsilinae	Mississippian	NL	CS
<i>Ptychobranchus subtentum</i>	Say, 1825	fluted kidneyshell	Lampsilinae	Cumberlandian	E	SC
<i>Quadrula apiculata</i>	Say, 1829	southern mapleleaf	Ambleminae	Mississippian ▼	NL	CS*
<i>Quadrula c.cylindrica</i>	Say, 1817	rabbitsfoot	Ambleminae	Mississippian	T	T
<i>Quadrula fragosa</i>	Conrad, 1835	winged mapleleaf	Ambleminae	Mississippian	NL	E
<i>Quadrula metanevra</i>	Raf., 1820	monkeyface	Ambleminae	Mississippian	NL	CS
<i>Quadrula nodulata</i>	Raf., 1820	wartyback	Ambleminae	Mississippian ▼	NL	CS

<i>Quadrula p.pustulosa</i>	Lea, 1831	pimpleback	Ambleminae	Mississippiian ▼	NL	CS
<i>Quadrula quadrula</i>	Raf., 1820	mapleleaf	Ambleminae	Mississippiian ▼	NL	CS
<i>Quadrula sparsa</i>	I. Lea, 1841	Appalachian monkeyface	Ambleminae	Cumberlandian	NL	E FE
<i>Quadrula tuberosa</i>	I. Lea, 1840	rough rockshell	Ambleminae	Cumberlandian	NL*	E* FE*
<i>Simpsonaias ambigua</i>	Say, 1825	salamander mussel	Anodontinae	Mississippiian	T	SC
<i>Strophitus undulatus</i>	Say, 1817	creeper	Anodontinae	Mississippiian	NL	CS
<i>Toxolasma lividus</i>	Raf., 1831	purple lilliput	Lampsilinae	Mississippiian	E	SC
<i>Toxolasma parvus</i>	Barnes, 1823	lilliput	Lampsilinae	Mississippiian	NL	CS
<i>Toxolasma texasensis</i>	I. Lea, 1857	Texas lilliput	Lampsilinae	Mississippiian	E	CS
<i>Tritogonia verrucosa</i>	Raf., 1820	pistolgrip	Ambleminae	Mississippiian ▼	NL	CS
<i>Truncilla donaciformis</i>	I. Lea, 1827	fawnsfoot	Lampsilinae	Mississippiian	NL	CS
<i>Truncilla truncata</i>	Raf., 1820	deertoe	Lampsilinae	Mississippiian ▼	NL	CS
<i>Uniommerus tetralasmus</i>	Say, 1831	pondhorn	Pleurobeminae	Mississippiian	NL	CS
<i>Villosa fabilis</i>	I. Lea, 1831	rayed bean	Lampsilinae	Mississippiian	E	SC
<i>Villosa iris</i>	I. Lea, 1829	rainbow	Lampsilinae	Mississippiian	NL	CS
<i>Villosa lienosa</i>	Conrad, 1834	little spectaclecase	Lampsilinae	Mississippiian	S	CS
<i>Villosa ortmanni</i>	Walker, 1925	Kentucky creekshell	Lampsilinae	Mississippiian	T	SC
<i>Villosa taeniata</i>	Conrad, 1834	painted creekshell	Lampsilinae	Cumberlandian	NL	CS
<i>Villosa trabilis</i>	Conrad, 1834	Cumberland bean	Lampsilinae	Cumberlandian	E	E FE
<i>Villosa v. vanuxemensis</i>	I. Lea, 1838	mountain creekshell	Lampsilinae	Cumberlandian	T	SC
AFS listing: E*=presumed extinct (12); E=Endangered (22); T=Threatened (7); U=Undetermined (19); CS=Currently stable (44); SC=special concern						
KSNPC listing: E=endangered (27); T=threatened (5); S=special concern (4); H=historic resource (1); NL=no listing (56)=total 93 species						
USFWS listing: FE*=presumed extinct (12); FE=Endangered (22); FT=Threatened (0); C=candidate (proposed for listing) (1)						
▼ also found in mainstem Mississippi River in Kentucky						