Kansas Recovery Plan for Freshwater Mussels in the Upper Osage River system, Kansas:

Mucket - *Actinonaias ligamentina*
Elktoe - *Alasmidonta marginata*
Rock Pocketbook - *Arcidens confragosus*
Purple Wartyback - *Cyclonaias tuberculata*

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EXECUTIVE SUMMARY

This recovery plan outlines strategies and methods to recover and eventually delist three freshwater mussel species native to the upper Osage River system in eastern Kansas. These mussels are the mucket (*Actinonaias ligamentina*), elktoe (*Alasmidonta marginata*), and rock pocketbook (*Arcidens confragosus*). Information about the purple wartyback (*Cyclonaias tuberculata*), which was recently discovered in Kansas and has yet received formal listing status, is also presented.

The mucket is currently found in the Marais des Cygnes River and, perhaps, Marmaton River. Only two records for the elktoe are known for the upper Osage River system, and its current status here is uncertain. This species is also found in the Spring River in Cherokee County. The rock pocketbook is found in limited numbers in the Marais des Cygnes River and possibly in Pottawatomie Creek and the Marmaton River. The purple wartyback is found only in the lower Marmaton River near the KS-MO border.

The recovery plan integrates two approaches for the recovery of these species: species-level and ecosystem. The ecosystem approach examines watersheds pertinent to all state-listed mussel species that occur in the upper Osage River system, and proposes practices that could improve watershed health. This approach will also benefit non-target species associated with riverine habitats. The species-level approach involves projects such as life history and demographic studies, as well as propagation of mussels into stream reaches where they have become extirpated.

The estimated five-year cost of implementing proposed recovery tasks is in excess of $182,750. Additional costs, such as landowner participation in the state income tax incentive program and government conservation programs, are not included because these costs will be dependent upon landowner acceptance of such programs. Downlisting dates cannot be estimated because it may require up to ten years to fully assess population trends, and because funding is presently not available for many of the recovery tasks outlined in this plan.

CONTENTS

LIST OF FIGURES AND TABLES

FIGURES

TABLES

I. Introduction

This recovery plan addresses the recovery needs for three state listed freshwater mussel species that occur in the upper Osage River system of east-central Kansas. These mussels are the mucket (*Actinonaias ligamentina*), elktoe (*Alasmidonta marginata*), and rock pocketbook (*Arcidens confragosus*). The elktoe also resides in a few mile reach of the Spring River in Cherokee County, but this recovery plan focuses on watersheds in the upper Osage River system; a state recovery plan has already been developed that addresses the recovery needs of mussels, including the elktoe, in the Spring River (Obermeyer 2000a). Information about a fourth species, the purple wartyback (*Cyclonaias tuberculata*), is also presented.

The elktoe and rock pocketbook received legal protection by KDWP in 1986 under the authority of the state's Nongame and Endangered Species Conservation Act of 1975. In 1992 their listing status was upgraded from SINC (species in need of conservation) to Threatened (rock pocketbook) and Endangered (elktoe) (K.A.R. 115-15-1 and 115-15-2). The mucket received legal protection as a state endangered species in 1999. Because the purple wartyback was only recently discovered as extant in the state (Obermeyer 2000b; Mulhern *et al.* 2002), its listing status is still under review.

This plan, as governed by K.A.R. 115-15-4, outlines specific strategies and methods to recover and eventually delist the mucket, elktoe, and rock pocketbook. The plan also provides a process of conserving other state-listed mussels (Table 1) that may occur in the upper Osage system in east-central Kansas.

A. Overview of recovery area

The upper Osage River system is located in the Central Irregular Plains ecoregion (Omernik 1987) in Kansas and Missouri, and is situated in the Ozark faunal province of the Mississippi River system (Johnson 1980). The watershed of the upper Osage River system was historically tallgrass prairie, with riparian forests bordering most perennial streams. Most of these prairies have been converted to cropland and other agricultural uses, and many of the riparian forests along major streams have been reduced in width. The only significant remaining area of native prairie is located in the western portion of the Marais des Cygnes watershed.

TABLE 1. ***Status, distribution, and potential hosts of imperiled mussels that historically occurred in the upper Osage River system in east-central Kansas.***

Species	State Status	Potential hosts found in the upper Osage River system
mucket (*Actinonaias ligamentina*)	Endangered	green sunfish and freshwater drum
elktoe *(Alasmidonta marginata)*	Endangered	northern hogsucker, shorthead redhorse, warmouth and white sucker
rock pocketbook (*Arcidens confragosus*)	Threatened	American eel*, gizzard shad, white crappie, freshwater drum and channel catfish
purple wartyback (*Cyclonaias tuberculata*)	Under review	black bullhead, channel catfish, flathead catfish and yellow bullhead
spectaclecase (*Cumberlandia monodonta*)	Extirpated	unknown
butterfly *(Ellipsaria lineolata)*	Threatened	freshwater drum and green sunfish
deertoe *(Truncilla truncata)*	SINC	freshwater drum
ellipse *(Venustaconcha ellipsiformis)*	Endangered	banded sculpin, bluntnose minnow, fantail darter, greenside darter, Iowa darter*, Johnny darter, logperch, orangethroat darter[c] and redfin darter[c]
fatmucket *(Lampsilis siliquoidea)*	SINC	black crappie, bluegill, bluntnose minnow, common shiner, largemouth bass, longear sunfish, orangespotted sunfish, smallmouth bass, striped shiner, tadpole madtom, walleye, white bass, white crappie and white sucker *yellow perch,*
fawnsfoot *(Truncilla donaciformis)*	SINC	freshwater drum
flutedshell *(Lasmigona costata)*	Threatened	banded darter, common carp and northern hogsucker
black sandshell (*Ligumia recta*)	Extirpated	American eel*, bluegill, common carp, green sunfish, largemouth bass, orangespotted sunfish and white crappie
round pigtoe *(Pleurobema sintoxia)*	SINC	bluegill, bluntnose minnow and northern redbelly dace
snuffbox (*Epioblasma triquetra*)	Extirpated	Logperch
spike *(Elliptio dilatata)*	SINC	black crappie, flathead catfish, gizzard shad and white crappie
creeper (= squawfoot) *(Strophitus undulatus)*	SINC	banded darter, black bullhead, bluegill, bluntnose minnow, creek chub, fantail darter, fathead minnow, golden shiner, green sunfish, largemouth bass, sand shiner, walleye, yellow bullhead and white crappie
Wabash pigtoe *(Fusconaia flava)*	SINC	black crappie, bluegill, creek chub and white crappie
washboard *(Megalonaias nervosa)*	SINC	American eel*, black bullhead, black crappie, bluegill, central stoneroller, channel catfish, flathead catfish, freshwater drum, gizzard shad, green sunfish, highfin carpsucker, largemouth bass, logperch, longear sunfish, longnose gar, slenderhead darter, tadpole madtom, white bass and white crappie
wartyback *(Quadrula nodulata)*	SINC	black crappie, bluegill, channel catfish, flathead catfish, largemouth bass and white crappie
yellow sandshell *(Lampsilis teres)*	SINC	black crappie, green sunfish, largemouth bass, longnose gar, orangespotted sunfish, shortnose gar, and white crappie

[b] Species targeted in the recovery plan; [c] Inferred host; * = presumed extirpated.

Streams within the Kansas portion of the upper Osage River system that are known to hold one or more of the mussels targeted in this recover plan include the Marais des Cygnes River, Marmaton River, and Pottawatomie Creek. The largest of these streams, the Marais des Cygnes River[1], exits the state as a 6th order stream and has a drainage area of approximately 3,330 sq. miles. From its source in Wabaunsee County to the state line, the Marais des Cygnes River is approximately 150 river miles in length (Schoewe 1951). Between its source to about Quenemo (in eastern Osage County), the river's gradient is more than 5 ft. (feet per mile), whereas the gradient from Quenemo to Osawatomie is 1.53 ft., and only 1.10 ft. from Osawatomie to the state line (Schoewe 1951). Pottawatomie Creek is the next largest stream in the upper Osage system in Kansas. Pottawatomie Creek is a 5th order stream at its confluence with the Marais des Cygnes River in Miami County near Osawatomie, and has a drainage area of 540 square miles. The Marmaton River, which has a drainage area of 432 square miles in Kansas, exits the state in Bourbon County as a 4th order stream.

The hydrology of these streams have changed substantially. The Marais des Cygnes River, for example, is influenced by three federal reservoirs (Pomona, Melvern, and Hillsdale lakes), along with many smaller impoundments. The hydrology of this river is also impacted by water extraction by private and public entities (e.g. municipalities, agricultural irrigators, La Cygne Power Plant), particularly in the lower reaches of the river (Obermeyer 2000b). In Missouri, approximately 82 percent of the Marais des Cygnes/Osage River has been impacted by channelization and impoundments. Construction of Lake of the Ozarks (completed in 1930) and Harry S. Truman Reservoir (completed in 1978) inundated many miles of the mid and lower Osage River. The Bates County Drainage Ditch (completed in the early 1920s) diverts flow from approximately 42 miles of the former channel of the Marais des Cygnes River. Less than nine miles of the original river channel remain upstream from Truman Reservoir in Missouri. Because of the permanent loss of habitat from the Missouri portion of the Marais des Cygnes/Osage River, the only opportunity to protect freshwater mussels in this system is in Kansas.

Like many watersheds in the Midwest, water quality in the upper Osage River system does not yield high marks. Sediment and nutrient loads are believed to be much above historic levels

[1] For many years, the upper reaches of the Osage River was officially referred to by the federal government as the Osage River, despite opposition by the state of Kansas, which passed legislation in 1917 that made it mandatory to use Marais des Cygnes River on all State-printed maps. In 1950, the U.S. Board on Geographic Names officially renamed the upper Osage River, upstream from its confluence with the Little Osage River in Missouri, as the Marais des Cygnes River (Schoewe 1951).

because of agricultural and other inputs (Obermeyer *et al.* 1997a). The Fort Scott and Ottawa waste water treatment plants also contribute to nutrient loads. Also, residual chlorine in wastewater from these facilities can react with effluent ammonia to form chloramines, which can be toxic to freshwater mussels (Goudreau *et al.* 1993). As a consequence, this effluent can cause the extirpation of mussels downstream (Stansbery and Stein 1976, Goudreau *et al.* 1993). Waste water treatment facilities can be a particularly a problem during periods of low flow, which usually coincide with high water temperatures and low dissolved oxygen. The entire flow of the lower Marmaton River is during low flow periods is derived entirely from the out flow of Fort Scott's waste water treatment facility (Obermeyer 2001) (Figure 1).

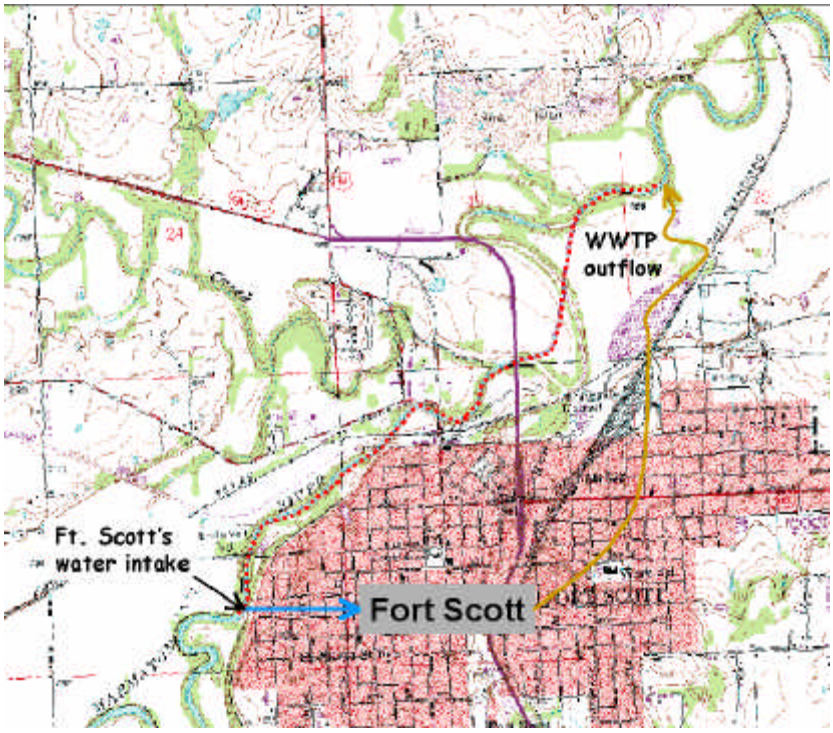

Figure 1. Hydrology of the Marmaton River at Fort Scott, KS.

Mussel fauna of the Upper Osage system.—A reported 46 species have been documented in the Osage River system (see Appendix 1; Scammon 1906, Utterback 1915, Murray and Leonard 1962, Stansbery 1972, 1974, Grace and Buchanan 1981, Oesch 1984, Buchanan *in litt.*, Obermeyer 2000b, Mulhern *et al.* 2002), including the four species targeted in this recovery plan. Four mussel species historically documented in the upper Osage River system are now believed to be extirpated from Kansas: snuffbox, black sandshell, spectaclecase, and slippershell. Four additional are state listed as endangered (mucket, elktoe, and flat floater), three are threatened (flutedshell and rock pocketbook), and 11 are listed as species in need of conservation (Appendix A).

II. Species Accounts

A. MUCKET — *ACTINONAIAS LIGAMENTINA*

1. Taxonomy and Description

Original Description.—*Unio ligamentina* Lamarck 1819, Histoire naturelle des Animaux sans Vertebres. 8 volumes.

Taxonomic Discussion.—Shell characteristics of the mucket and Neosho mucket (*Lampsilis rafinesqueana*) are very similar (Obermeyer, 2000a). However, the two species can be separated by locality information; i.e., *A. ligamentina* does not occur in the Arkansas River system (Obermeyer 2000). These species can also be separated anatomically. The mantle edge of the mucket is light to dark brown (Ortmann 1912), whereas the mantle edge of the Neosho mucket is orange with dark markings (Oesch 1984). The shell of the mucket can also be confused with the fatmucket (*Lampsilis siliquoidea*), plain pocketbook (*L. cardium*), and butterfly (*Ellipsaria lineolata*) females.

Shell Description (Figure 2).— The shell of the mucket is smooth and relatively thick, and the outline of shell is oblong to elliptical. Maximum shell length for the species is 178 mm (Cummings and Mayer 1992). The anterior and ventral margins of shell are gently rounded. Beaks extend only slightly beyond the hinge line. The periostracum is olive-yellow to dark brown, with solid green rays in younger specimens. The left valve has two pseudocardinal teeth, whereas the right valve has one erect tooth. The interdentum is relatively broad in Kansas specimens and typically extends about the same distance in length as the lateral tooth, which curves slightly downward. The nacre is creamy white with iridescence at the posterior end.

Figure 2. *Actinonaias ligamentina*, Marais des Cygnes River, Franklin Co. (Photo courtesy of KDHE)

2. Historical and Current Distribution

Historical Distribution.—The mucket historically occurred in the Osage and Kansas river systems, including Mill Creek and the Kansas, Wakarusa, and Marais des Cygnes rivers (Scammon 1906). Weathered valves of the mucket have also been collected from Pottawatomie Creek and the lower Marmaton River (Mulhern *et al.* 2002). It is believed that the mucket is extirpated from most of its historic range outside of the upper Osage River system, with the possible exception of Mill Creek. However, the absence of survey work in this stream makes it impossible to determine the species presence there.

Current Kansas Distribution.— In 1996, a live individual and a freshly dead specimen (KDHE MC96266) were discovered in a gravelly riffle in the Marais des Cygnes River near Ottawa (Miller 1997, Mulhern *et al.* 2002). In 1997, another live individual and several recently dead specimens were discovered in a gravelly reach of the Marais des Cygnes River in eastern Franklin County (Miller, 1998). Two unweathered specimens were recovered in 1994 in Pottawatomie Creek near Lane (Franklin Co.), and an articulated specimen with unweathered nacre (KDHE MC99045) was collected in 1999 from the Marmaton River in Bourbon County, approximately 5.6 km west of Fort Scott, KS.

3. Reproduction and Habitat

Reproduction.—The breeding season for the mucket is from August to May (Surber 1912). Known hosts for the mucket are green sunfish (*Lepomis cyanellus*) and freshwater drum (*Aplodinotus grunniens*) (Surber 1913, Howard 1914, Wilson 1916, Coker *et al.* 1921, Howard and Anson 1922).

Habitat.—The mucket is found in small to large rivers and occasionally reservoirs; it is seldom found in smaller headwater streams (Gordon and Layzer 1989). In smaller rivers, it is typically found at depths less than 1 m in riffle habitat. In larger rivers, habitat use varies from shallow areas to pools at depths greater than 4 m (Gordon and Layzer 1989). Buchanan (1980) found it in Missouri most often in silt and in gravel/cobble substrates.

4. Designated Critical Habitat (Figure 3)

Critical habitat:

- *Marais des Cygnes River*: from the confluence of Hundred and Ten Mile Creek (Osage-Franklin Co. border) to the Kansas-Missouri border (Linn Co.).
- *Pottawatomie Creek*: from the confluence of the South Fork of Pottawatomie Creek (Anderson Co.) to the confluence of the Marais des Cygnes River (Miami Co.).
- *Marmaton River*: from the confluence of Paint Creek to the City of Fort Scott (Bourbon Co.).

Critical habitat, but lacking recent documentation of the species:

- *Marais des Cygnes River*: from Melvern Reservoir to the confluence of Hundred and Ten Mile Creek (Osage-Franklin Co. border).
- *Marmaton River*: from the City of Fort Scott to the Kansas-Missouri border (Bourbon Co.).
- *Outside of the Osage system:* Mill Creek (Wabaunsee Co.); Wakarusa River (Douglas Co.).

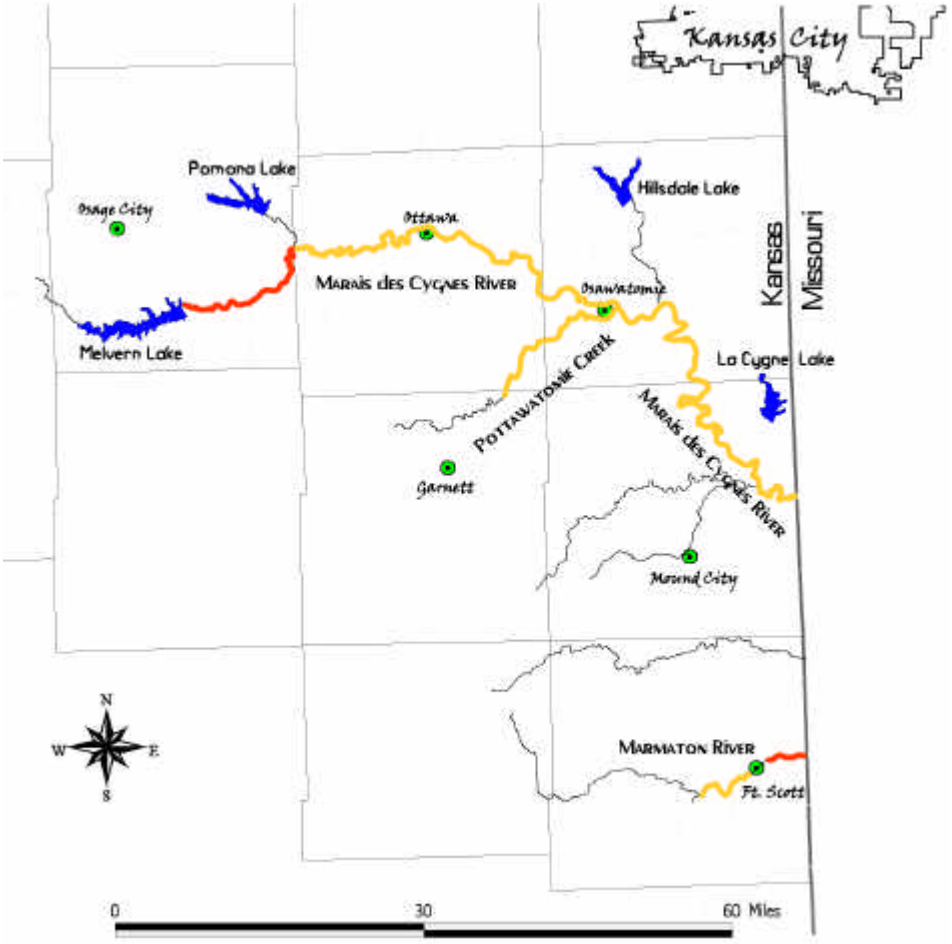

Figure 3. Critical habitat for the mucket in the upper Osage River system in east-central Kansas. Reaches highlighted in yellow represent habitat likely supporting populations, whereas areas in red lack recent documentation for the species.

B. ELKTOE — *ALASMIDONTA MARGINATA*

1. Description

Original Description.—*Alasmidonta marginata* Say 1818, Descriptions of a new genus of fresh water bivalve shells, Journal of the Academy of Natural Sciences of Philadelphia, 1:459-460 [reprinted in W.G. Binney, 1858:62-63]; type locality: Scioto River [Ohio]; comments: type material is presumed lost (Baker and Johnson 1973).

Shell Description (Figure 4).—The shell of the elktoe is smooth other than concentric growth-rest lines, elongate, inflated, and thin but not fragile. The anterior end is rounded, the ventral margin is straight to slightly curved, and the posterior end is truncated with ridges on the posterior slope. The posterior ridge is prominent and sharply angled. Umbos are large and elevated above the hinge line. Beak sculpturing consists of thick, double-looped ridges. The periostracum is yellowish green, with numerous green rays and specks. Two remnant pseudocardinal teeth are in the left valve and one in the right valve. Lateral teeth are missing in both valves, with only a thickened swelling along the hinge line. The beak cavity is moderately deep. Nacre is bluish white with a hint of iridescence, occasionally with shades of pink posteriorly.

Figure 4. *Alasmidonta marginata.* (Ohio State University collection)

2. Historical and Current Distribution

Distribution.— The elktoe is widely distributed throughout eastern North America, being found in 22 states and one Canadian Province (Clarke 1981, Williams *et al.* 1993). Oesch (1984) described the elktoe as widely distributed in the southern-half of Missouri, but noted that it is uncommon at any one locale.

The elktoe was first documented in Kansas by Branson (1966), who found three live specimens in the Spring River in 1964. Cope (1985) also recovered the species in a short reach of the Spring River, from where the river first enters Kansas to just upstream from the confluence of Center Creek (Cherokee Co.). Although additional live and freshly dead specimens have since been collected in the Spring River (Obermeyer *et al.* 1995, 1997b), earlier surveyors (Branson 1967, Cope 1985) found the species more frequently and at more Spring River sites. The only other stream record for the species in Kansas is from the Marais des Cygnes River, Franklin County, based on a recently dead specimen collected in 1983 (Distler and Bleam 1987). Weathered shells of this species have been recovered at two additional Spring River sites in Kansas and one weathered valve was found at a Shoal Creek site in Missouri, which is the first account of this species in Shoal Creek (Clarke and Obermeyer 1996, Obermeyer 1997b).

3. Reproduction and Habitat

Reproduction.— Five potential hosts have been identified for the elktoe (Howard and Anson 1923), which is a bradytictic breeder (Ortmann 1919, Oesch 1984, Watters 1994). These are the northern hog sucker (*Hypentelium nigricans*), rock bass (*Ambloplites rupestris*), shorthead redhorse (*Moxostoma macrolepidotum*), warmouth (*Lepomis gulosus*), and white sucker (*Catostomus commersoni*).

Habitat.— The elktoe is reported to prefer riffles in cobble-gravel and gravel-sand substrates in medium to large rivers (Clarke and Berg 1959, Clarke 1981; Cummings and Mayer 1992), with a preference for moderate to swift currents (Clarke and Berg 1959; Gordon and Layzer 1989). The species is also known to occur in macrophyte beds (Baker 1928, Clark and Berg 1959, Buchanan 1980). In Kansas, the elktoe has been collected in swift riffles up to about 50 cm depth in predominantly cobble substratum (Obermeyer et al. 1997).

4. Designated Critical Habitat (Figure 5)

Critical habitat:

- *Spring River*: from where the Spring River first enters Kansas to US-66 (Cherokee Co.).
- *Marais des Cygnes River*: from the confluence of Hundred and Ten Mile Creek (Osage-Franklin Co. border) to the confluence of Pottawatomie Creek.

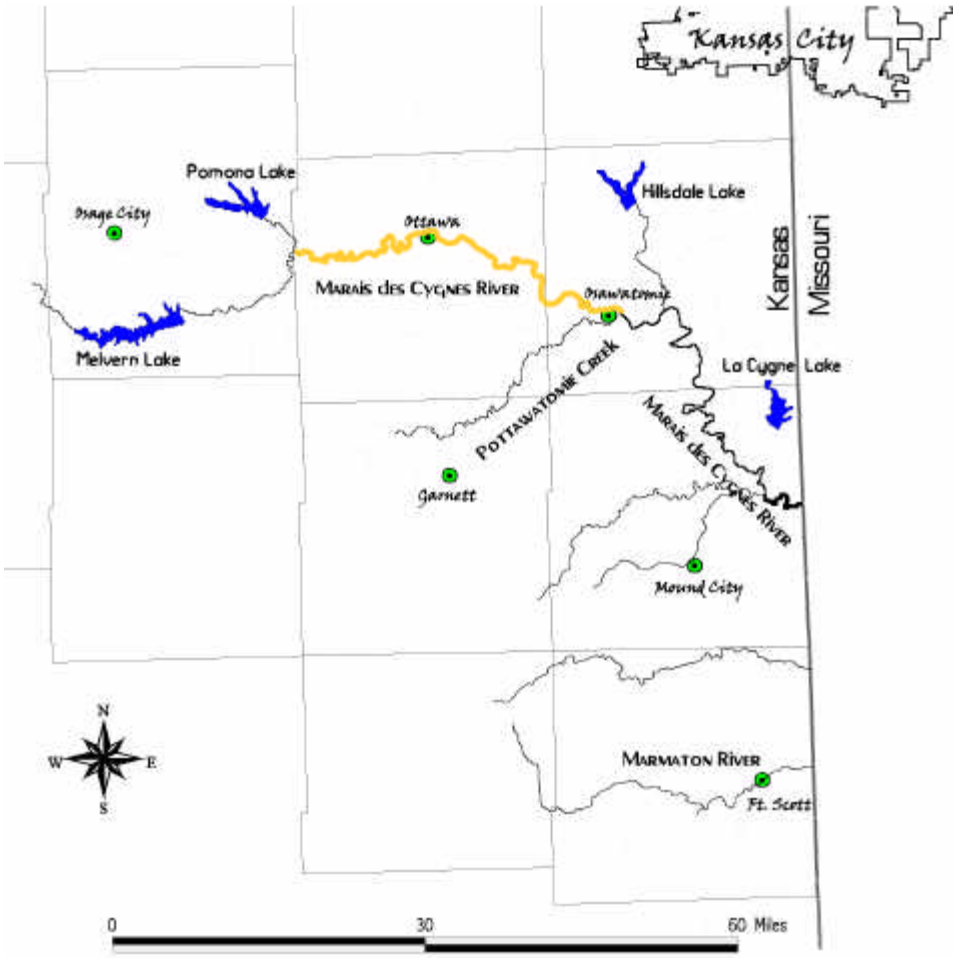

Figure 5. Critical habitat for the elktoe in the upper Osage River system in east-central Kansas. Reaches highlighted in yellow represent habitat that may populations.

C. ROCK POCKETBOOK — *ARCIDENS CONFRAGOSUS* (SAY 1829)

1. Taxonomy and Description

Original Description.—*Alasmidonta confragosus Say, 1829*, Descriptions of some new terrestrial and fluviatile shells of North America. The New Harmony Disseminator of Useful Knowledge (New Harmony), Indiana) 2(20): 339-341. [Reprinted by W.G. Binney, 1858.] Type material not found in Academy of Natural Sciences of Philadelphia (Johnson and Baker 1973) and presumed lost (Clarke 1981); type locality: "A side stream of the Wabash called Fox River [Indiana]".

Shell Description (Figure 6).—The shell is inflated, moderately thick in Kansas specimens, and the outline of shell is rhomboid. Maximum shell length in Kansas (Marais des Cygnes River) is 162 mm (Obermeyer 1994). Beaks are prominent and rise above the hinge line, about one-third from the anterior end. Beak sculpturing is pronounced with double-looped ridges that blend into ridges on the remaining third of the shell. Periostracum can be dark green, brown or black. The left valve has two pseudocardinal teeth, whereas the right valve has one. Pseudocardinal are compressed and elongate in both valves. Lateral teeth are poorly developed in both valves, consisting of serrated ridges. Beak cavity is moderately deep. Nacre is white with iridescence posteriorly.

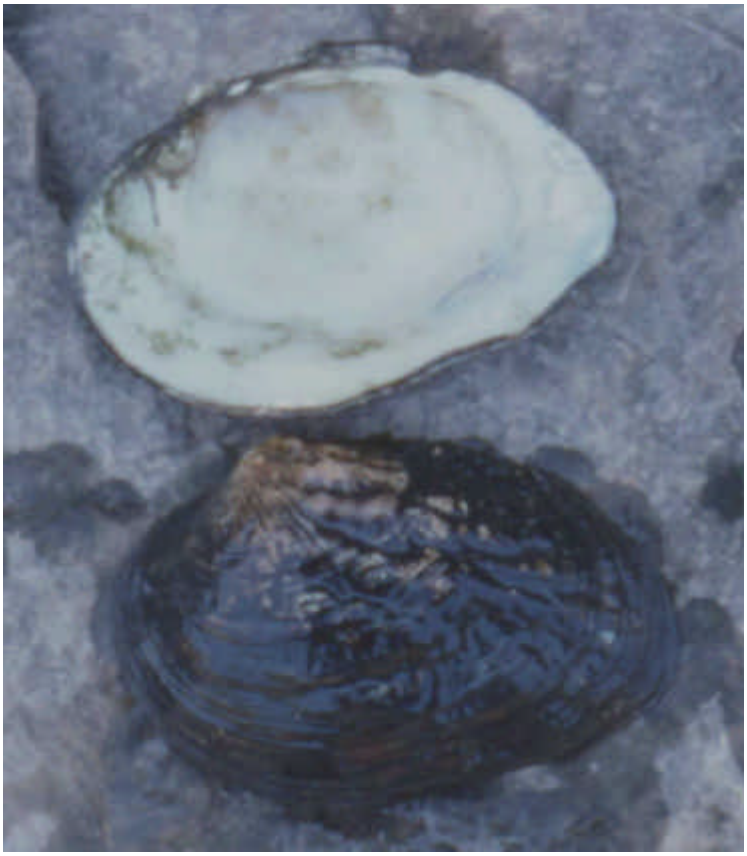

Figure 6. *Arcidens confragosus,* Marais des Cygnes River, Miami Co., KS.

2. Historical and Current Distribution

Distribution.— Unweathered, disarticulated valves of the rock pocketbook were collected by KDHE from Pottawatomie Creek in Franklin County each year during the periods 1993-1994 and 1997-2000. In 1994 and 1997, unweathered valves were also collected by KDHE from the Marais des Cygnes River in Linn and Franklin Counties, respectively. A relatively recent valve of this mussel was also collected from the Marais des Cygnes River west of Osawatomie in Miami County (Obermeyer 1994). In August 2000, a relatively recent valve of this species was collected from the Marmaton River approximately 8 km from the state line (Obermeyer 2001). One live individual and two freshly dead specimens were collected from the Marais des Cygnes River at Ottawa in 1996 (Couch 1997, Miller 1997). The following year, three live specimens were collected from the Marais des Cygnes River in Miami County (Miller 1998). These live individuals are the first reported for the rock pocketbook in Kansas since 1949 (Murray and Leonard 1962).

3. Reproduction and Habitat

Reproduction. The rock pocketbook is bradytictic with recorded breeding dates from September to June (Utterback 1915, Baker 1928). Known hosts include the American eel (*Anguilla rostrata*), channel catfish (*Ictalurus punctatus*), freshwater drum (*Aplodinotus grunniens*), gizzard shad (*Dorosoma cepedianum*), rock bass (*Ambloplites rupestris*), and white crappie (*Pomoxis annularis*) (Surber 1913, Wilson 1916, Howells 1994, 1997).

Habitat.—The rock pocketbook is most often found in low gradient rivers with sand and mud bottoms, but may also be found in medium-sized streams in courser substrates and in sloughs (Layzer and Gordon 1989, B. Obermeyer, pers. observ.). In Missouri, Buchanan (1980) found the rock pocketbook in silt to cobble substrates at depths of 4 inches to 3.5 feet with little or no current.

4. Designated Critical Habitat (Figure 7)

Critical habitat currently occupied:

- *Marais des Cygnes River*: from the confluence of Hundred and Ten Mile Creek (Osage-Franklin Co. border) to the Kansas-Missouri border (Linn Co.).
- *Pottawatomie Creek*: from the confluence of the South Fork of Pottawatomie Creek (Anderson Co.) to the confluence of the Marais des Cygnes River (Miami Co.).

Critical habitat, but lacking recent documentation of the species:

- *Marmaton River*: from the outflow of Fort Scott's waste water treatment facility to the Kansas-Missouri border (Bourbon Co.).

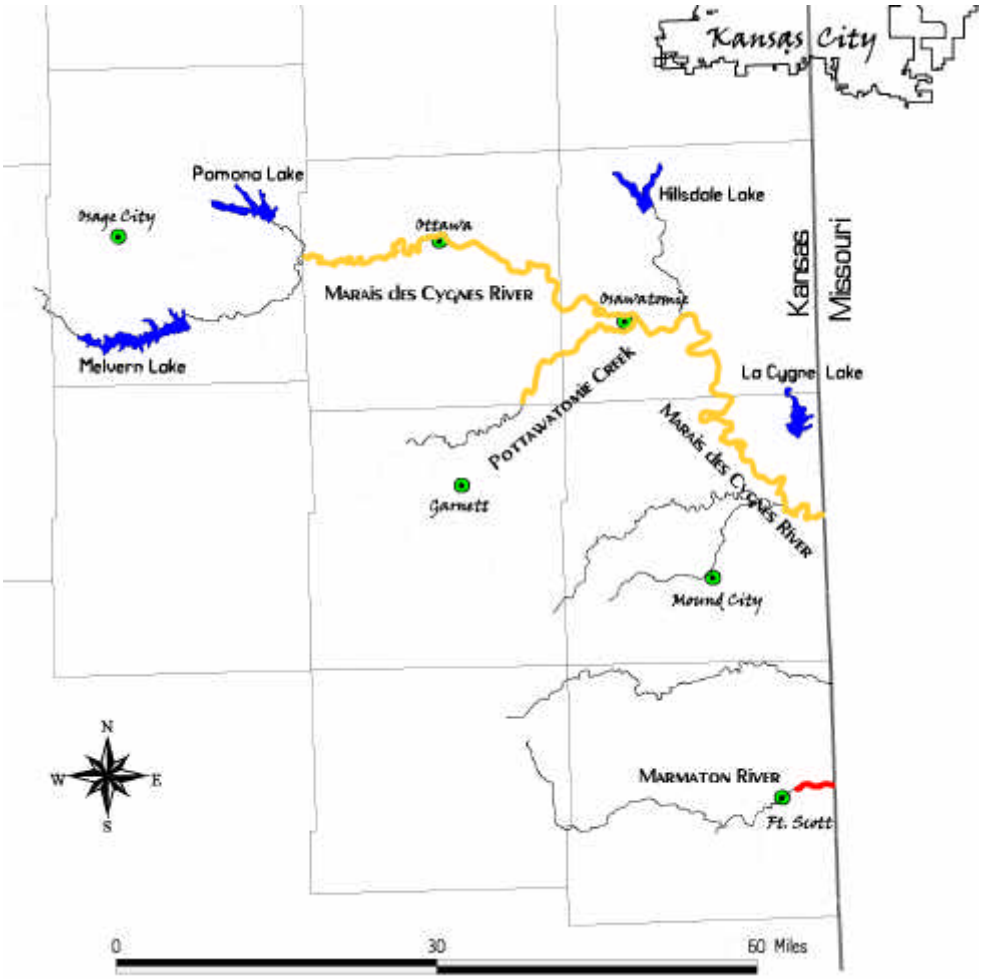

Figure 7. Critical habitat for the rock pocketbook in the upper Osage River system in east-central Kansas. Reaches highlighted in yellow represent habitat likely supporting populations, whereas areas in red lack recent documentation for the species.

D. PURPLE WARTYBACK — *CYCLONAIAS TUBERCULATA* (RAFINESQUE 1820)

1. Description

Original Description.—*Obliquaria (Rotundaria) tuberculata* (Rafinesque, 1820); Monographie des coquilles bivalves fluviatiles de la Rivière Ohio, contenant douze genres et soixante-huit especes. Annales genéralés des sciences Physiques, a Bruxelles vol.. 5; type locality: Ohio River.

Shell Description (Figure 8).—The shell of the purple wartyback is circular, sturdy, and thick. In smaller streams, shells are compressed with inconspicuous beaks, whereas in larger streams shells are moderately inflated with prominent beaks. Beak sculpturing consists of wavy ridges covering the surface of the beak. The center and posterior surfaces of the shell are covered with small tubercles, which are arranged parallel to the growth-rest lines. The periostracum is yellowish brown to dark brown, with occasional greenish rays in young specimens. Pseudocardinal teeth are large and deeply serrated. The left valve has two teeth whereas the right valve has a single tooth. The interdentum is wide and flat. The well-developed lateral teeth are short, striated, and usually curved. Beak cavity is relatively deep. Nacre ranges from deep purple throughout to light purple in the center of shell fading to nearly white along the edge of shell. Length up to 130 mm (Parmalee and Bogan 1998).

Figure 3. *Cyclonaias tuberculata*. (Ohio State University collection)

2. Historical and Current Distribution

Distribution.— A disarticulated weathered valve of the purple wartyback (KU 001250) was collected on 2 August 1999 in the Marais des Cygnes River, Linn County, approximately 2.4 km upstream from the Kansas-Missouri state line (Obermeyer 2000, Mulhern *et al.* 2002). On 25 August 2000, one live and two freshly dead specimens of the purple wartyback were found at the same site (Obermeyer 2000b). One of the freshly dead specimens was deposited at the Museum of Natural History, University of Kansas (KU 001248).

3. Reproduction and Habitat

Reproduction.— The purple wartyback is tachytictic, with its reproductive period is from June to August (Utterback 1916). Known hosts for the purple wartyback include the black bullhead (*Ameiurus melas*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), and yellow bullhead (*Ameiurus natalis*) (Hove *et al.* 1994, Hove *et al.* 1997, Hove 1997).

Habitat.—The purple wartyback inhabits medium to large rivers in a variety of substrates. In smaller streams, the species may be found at depths less than 1 m in areas of moderate to swift current, whereas in larger rivers it can be found at depths up to 20 feet (Gordon and Layzer 1989, Parmalee and Bogan 1998). It also may be found in mud substratum near the stream bank or near macrophyte beds (Gordon and Layzer 1989). Buchanan (1980) found it most often in Missouri in gravel and cobble substrates at depths up to 5 feet.

5. Critical Habitat

Critical habitat currently occupied:

- *Marais des Cygnes River*: from the US 69 bridge near Trading Post to the Kansas-Missouri border (Linn Co.).

III. RECOVERY

A. OBJECTIVES

The ultimate objective of this recovery plan is to restore populations of the three targeted mussel species so they can be removed from the Kansas list of endangered, threatened, and SINC species. Another objective of this recovery plan is the recovery—through watershed enhancements—of other state-listed mussel species that occur in the upper Osage River system of east-central Kansas (Table 1).

Both a species-level and ecosystem/watershed approach will be required for the recovery and subsequent delisting of these mussels. Species-level actions are sometimes required even in relatively healthy systems, because natural recolonization may be insufficient to balance extinction in fragmented populations (Vaughn 1993). As an example, this recovery plan recommends reestablishing the targeted species into stream reaches where they have become extirpated. To restore biological integrity of streams, an ecosystem or watershed approach is the most appropriate method. River restoration may require, for example, changing dam operations to mimic natural flows and implementing land management practices that help reduce the delivery of nutrients and sediments into streams.

B. RECOVERY CRITERIA

The four target species should be considered for listing reclassification when: i.) recovery tasks outlined in *Section III—C* have been initiated or completed and ii.) populations are protected from current and foreseeable threats that might jeopardize their continued existence. Under such circumstances, KDWP's formal petition listing process will be followed. Recovery criteria specific to each species are summarized in Table 3.

TABLE 2. ***Downlisting criteria for the elktoe, mucket, and rock pocketbook in east-central Kansas.*** *In addition to the following criteria, downlisting will require completion or initiation of recovery tasks outlined in Section III—C and that populations are protected from any current and foreseeable threats that might jeopardize their continued existence.*

Species	Downlisting steps	Downlisting criteria
Elktoe	*Downlist to threatened*	A minimum of two viable local populations[1] present in each of the Spring and Marais des Cygnes rivers. A minimum of three age classes shall be present, one of which has naturally produced within five years of the downlisting date. Suitable host fishes must be present.
	Downlist to SINC	Same as above except that four local populations must be present in each of the above mentioned rivers. Also, a population shall be reestablished in the lower Spring River (downstream from Empire Lake). Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' known historical range in Kansas.
Mucket	*Downlist to threatened*	A minimum of two local populations present in each of the Marais des Cygnes and Marmaton rivers and in Pottawatomie Creek. A minimum of three age classes must be found in these populations, one of which has naturally produced within five years of the downlisting date. Gravid females and suitable host fishes must be present.
	Downlist to SINC	Same as above, except a combined total of 12 local populations must be present in the above mentioned streams. Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' know historical range in the upper Osage River system.
Rock pocketbook	*Downlist to SINC*	A minimum of 12 local populations present in the Marais des Cygnes and Marmaton rivers and in Pottawatomie Creek, with a minimum of three age classes, one of which that has naturally produced within five years of the downlisting date. Also, a minimum of two local populations must be present within each stream. Gravid females and suitable host fishes must also be present. Reestablished populations must be self-perpetuating, with gravid females and suitable host fishes present.
	Delist	Self-perpetuating populations present throughout 75% of the species' known historical range in Kansas.

[1] A viable, local population is defined as a group of reproducing individuals separated by barriers or unsuitable habitat (*e.g.* a riffle site isolated by unsuitable habitat by distances greater than 10 km).

IV. NARRATIVE OUTLINE

1. Protect existing populations and occupied habitats of state-listed mussels in the Marais des Cygnes and Marmaton rivers, and Pottawatomie Creek. Preservation of existing populations and critical habitats is essential in order to restore these species.

   1.1. Promote stewardship to protect and/or restore essential habitats for the recovery of state-listed mussels and to reduce nonpoint source pollution. Because most Kansas streams and watersheds are privately owned, the willingness of landowners to participate in recovery activities is essential for the recovery of these mussels and critical habitats.

      1.1.1. Provide state income tax incentives to landowners who voluntarily enter into recovery plan agreements to protect and/or restore instream and riparian habitats. A recovery plan agreement must meet the following criteria: i.) participant shall carry out management activities specified in a recovery plan; ii.) property meets habitat designation criteria for the targeted T&E species; iii.) agreement shall be no less than five years; and iv.) KDWP and other essential personnel will have access to the property for the duration of the agreement for monitoring purposes. In exchange, landowners would receive state income tax credits equal to the amount of property taxes paid on acreages deemed by KDWP as necessary for the recovery of state-listed mussels and for costs incurred while complying with recovery plan agreements. Project eligibility will be dependent upon location (Appendix B). Tax credits would be granted for each year's enrollment in a recovery plan agreement. Before an agreement is signed, KDWP will outline the procedure for applying for state income tax credit.

         1.1.1.1. Offer state income tax credits to landowners who agree to protect and restore riparian habitats. Eligible practices include maintaining and/or enhancing riparian habitats (see Appendix B for riparian buffer criteria), planting native vegetation along streams to serve as riparian buffers (Appendix C), preserving or restoring wetlands that are in the 100-year flood zone, and excluding livestock from riparian habitats and streams by building fences and developing alternative watering sources for livestock. The implementation of grazing strategies that minimize riparian damage will be considered along smaller streams, but these practices must first be approved by KDWP.

         1.1.1.2. Provide tax credit incentives to farmers and ranchers who implement practices that reduce nonpoint source pollution. For example, planting buffer strips along riparian corridors can reduce nitrate and phosphorus concentrations from surface

runoff. Sites must be in a watershed with a HUC-11 (eleven-digit hydrologic unit code) point score of eight or more (Appendix B). Eligible practices include the entrapment and proper disposal of animal wastes from confined livestock and the planting of field buffers and grassed waterways to retard soil erosion. Refer to NRCS's Conservation Practice Standard Codes for technical specifications.

1.1.1.3. Provide tax credit incentives to landowners who participate in instream and channel rehabilitation projects, such as stream bank stabilization. Proposed instream and streambank stabilization projects must be approved by KDWP before being accepted into a recovery plan agreement.

1.1.1.3.1. Determine priority stream reaches and sites for instream and stream bank restoration projects. Streambank stabilization and instream projects may adversely affect channel morphology and instream habitats (both upstream and downstream). Because of possible risks to mussel habitats from such projects, only restoration sites with a high potential for benefiting mussels should be considered for inclusion into recovery plan agreements.

1.1.1.3.2. Review instream and stream bank restoration projects. Individual projects should be reviewed by experts (Task 12) to ensure that proposed projects would benefit mussels.

1.1.1.4. Provide tax credit incentives to landowners who grant stream access for research purposes. Because stream access is limited in Kansas, it is important to have a mechanism to acquire stream access for research purposes. A landowner of a desired research site would receive a state income tax credit equal to the amount of property tax for acreage on and near the research site, as well as acreage used for accessing the site. A landowner would also receive state income tax credit equal to costs incurred for the maintenance of access roads and other pertinent expenses related to the compliance of the recovery plan agreement. Research activities might include acquiring brood stock and suitable host fishes, seeding juvenile mussels for reintroduction/augmentation projects, and monitoring mussel populations and habitats.

1.1.1.5. Provide tax credit incentives to rural residents for non-mandated improvements to rural sewer systems in priority HUC-11 watersheds. Eligible sites must be within 100 m (~330 feet) of a perennial stream in a HUC-11 watershed with a point score

of eight or more (Appendix B). All rural sewer system improvements must meet KDHE minimum standards (K.A.R. 28-5-6 to 9).

1.1.2. Encourage landowners to participate in State and Federal conservation programs to rehabilitate watersheds. Funding is currently available for a wide variety of watershed enhancement projects from state and federal conservation programs.

1.1.3. Provide safe harbor agreements for participants in recovery plan agreements. Landowners may be reluctant to enter into recovery plan agreements if they think they could be penalized if an endangered species is discovered or introduced on their property. A safe harbor agreement requires that the participant maintains or enhances suitable habitat currently unoccupied by state-listed species. In return, the participant is protected from land use restrictions that might result if a state-listed species becomes established into the habitat. However, state-listed species already inhabiting a property at the time the landowner signs into a recovery plan agreement would remain fully protected under the state's Nongame and Endangered Species Conservation Act.

1.2. Identify areas of concentrated land use, and investigate ways to mitigate water quality concerns. Large disturbances may negate other watershed enhancement projects.

1.3. Develop partnerships with state and federal agencies, local governments, private organizations, industries, and individuals to identify, assess, and mitigate projects that might impact state-listed mussels and mussel habitats.

1.4. Integrate mussel die-off emergency response strategies with the existing fish kill cooperative agreement between KDWP and KDHE, which outlines investigation procedures. It is important that appropriate agencies and individuals be promptly notified of mussel and fish kills, chemical spills, and other environmental emergencies in streams where state-listed mussels occur.

1.5. Solicit expertise and funding in protecting the four targeted species and essential mussel habitats.

1.6. Utilize existing state and federal legislation and regulations to protect species and habitats. Habitat and water quality degradation are largely to blame for the current fate of these mussel species. Therefore, it is essential to enforce existing laws and regulations designed to address these concerns.

2. Improve the accessibility of historic and recent mussel distribution and demographic data.

2.1. Develop a centralized, georeferenced database of distribution data for mussels. Information regarding the distribution of Kansas' freshwater mussels (*e.g*. collections and databases maintained by KDWP, KDHE, Kansas Biological Survey, State universities, and individuals) is not readily accessible to any one individual or agency. Correcting nomenclature and identifications, and assembling this information into one georeferenced database are needed to identify distributional data gaps and to identify potential reintroduction sites. The database should include absence data and status information for presence data[1] of all mussels occurring in the state. The database would be linked to a GIS and made accessible to those involved in the conservation management of freshwater mussels.

2.2. Add species data as a resource element coverage to a GIS. Four categories of species data assembled by Task 2.1 would be tiled by HUC-11 boundaries, and added as resource element coverages to a GIS. These coverages would include the number of target species within each HUC-11 watershed (currently and historically), the number of extant state-listed species in each watershed, and the overall number of extant species in each watershed. This information would be used for making priority area designations (Appendix B).

2.3. Update distributional data with additional sampling in unsurveyed stream reaches. Fill distributional data gaps as identified in Task 2.1 and in the literature. This includes any reach of stream that is: 1.) within the historical range of one or more of the four target species, and 2.) lacking recent assessment of mussel populations in a stretch of stream exceeding 15 river km.

3. Conduct studies on life histories, population dynamics, and ecological requirements of target species. Knowledge of the biology and ecology of these species is inadequate to meet recovery objectives.

3.1. Conduct research related to the life histories of the four target species. Knowledge of each species' life history is essential in determining management guidelines for recovery.

3.1.1. Determine optimal fish hosts and period of spawning and gravidity for target mussel species.

3.1.2. Conduct ichthyofaunal surveys to determine the distribution and abundance of potential fish hosts for the targeted mussel species. Knowledge of the distribution and relative abundance of potential fish hosts is critical for the restoration of freshwater mussels.

[1] *i.e.* number of live specimens, recently dead valves, weathered valves, and relic or subfossil valves.

Priority streams and reaches include the Marais des Cygnes River from Melvern Reservoir to the KS-MO border, Marmaton River, and Pottawatomie Creek.

3.1.3. Initiate fish surveys at proposed reintroduction/augmentation sites (determined by Task 7.2). Potential fish hosts of target mussel species must be present to restore viable populations. Fish density and abundance data will be needed at proposed reintroduction sites.

3.2. Determine population characteristics of each target species, including age and size at sexual maturity, growth rates, reproductive longevity, and mortality rates. This information is needed to determine the number of individuals and level of recruitment required to maintain long-term viable populations.

3.3. Determine ecological requirements of each species.

3.3.1. Determine habitat and nutritional needs, particularly during the juvenile stage, for each of the four target species. Knowledge of habitat and nutritional requirements would assist in the rearing of juvenile mussels for propagation purposes.

3.3.2. Evaluate physiochemical variables that potentially limit recruitment and/or survival of the four target species. Because juvenile mussels are more sensitive to environmental stresses than adults (Dimock and Wright 1993, Warren *et al.* 1995, Pohlhill and Dimock 1996), they should be emphasized for study. This task could establish minimum habitat and water quality standards at recovery sites.

4. Conduct habitat and water quality studies for target mussel species.

4.1. Quantify instream habitats by measuring habitat variables along priority stream reaches and relate to mussel populations.

4.2. Evaluate riparian and stream habitats using remote sensing. Use aerial and satellite imagery to fill data gaps in unsampled stream reaches. Remote imagery could also be used to classify riparian habitats (Clemmer 1994, Prichard *et al.* 1999).

4.3. Evaluate the effect of regulated lake releases and current minimum flow standards to mussels. Evaluate the effect of stream flow on mussel populations, develop environmental instream flow requirements, and make recommendations to the U.S Army Corps of Engineers (USACE) and the Kansas Water Office (KWO).

4.4. Monitor river conditions of the lower Marais des Cygnes River (downstream from hwy 69) during droughts and other high water-use demand periods to ensure that adequate flows (>25 cfs) are maintained. Develop a contingency plan to address: 1) water-use negotiations

with private and public entities that may affect flows (*e.g.*, upstream USACE projects (Pomona, Melvern, and Hillsdale lakes) and the La Cygnes Power Plant), and 2) the salvage of stranded mussels, especially rarer species, if low flows can not be averted.

5. Study the impact to mussels from traditional wastewater disinfectants, and investigate the potential of converting municipal wastewater treatment plants (WWTPs) from chlorine to alternative disinfectant methods.

6. Work with appropriate agencies and Legislative Committees to develop guidelines for mining sand and gravel from alluvial channels and floodplains.

7. Initiate a reintroduction/augmentation program using propagated juveniles and, to a lesser extent, translocated adults. Adherence to USFWS guidelines to protect the genetic integrity of aquatic mollusks (Appendix D) should be considered for all reintroduction/augmentation projects to prevent the introduction of unfavorable genetic traits to the recipient population (Berg and Guttman 1998, Butler 1998).

   7.1. Establish experimental population boundaries for future reintroduction projects. Reintroduced populations would be classified as experimental populations (EP). A species' critical habitat designation would be reclassified to EP habitat if: i.) the species has not been documented extant during the past 35 years, based on tasks 2.1 - 2.3, and ii.) there are active reintroduction projects for the species within the stream reach under consideration. Landowners within the habitat boundaries of an experimental population would not be imposed with additional land-use restrictions.

   7.2. Establish priority sites for reintroduction/augmentation projects. Specific sites would be selected based on habitat evaluations, water quality, and other ecological considerations, such as the presence of suitable hosts.

   7.3. Initiate reintroduction projects for the four target species.

      7.3.1. Initiate a pilot reintroduction project using juveniles. .

      7.3.2. Initiate a reintroduction project by releasing fish (suitable hosts) infected with glochidia. This method of reintroduction would be less expensive than Task 7.3.1, although it is less likely to succeed in establishing new populations. Suitable hosts of target species would be collected at or near the reintroduction site, exposed to glochidia, then immediately returned to the stream.

8. Survey mussels in the upper Osage River system and develop a long-term monitoring program.

8.1. Establish long-term monitoring sites at locations where populations of target mussel species occur.

8.1.1. Initiate extensive qualitative survey of mussels in the upper Osage River system.

8.1.2. Initiate quantitative sampling sites in the Marais des Cygnes (3x) and Marmaton (2x) rivers and in Pottawatomie Creek (2x). Sample a minimum of 25, 1-m^2 quadrats at each site in a 100 m reach of habitat. Sites would be sampled at five-year intervals to assess population change.

8.1.3. Monitor mussel populations at reintroduction, augmentation, and translocation sites. Sites should be monitored annually for a minimum of five years following the release of propagated and/or translocated individuals. Thereafter, sites would be sampled at five-year intervals to evaluate long-term survival and reproductive success.

8.2. Reevaluate stream reaches within the historic range of the four target species using qualitative sampling methods to assess changes in species distribution, abundance, and diversity of freshwater mussels. Streams should be re-surveyed at no less than ten-year intervals.

9. Prepare for the likely invasion of zebra mussels and other nonindigenous species. Although the zebra mussel is not presently found in Kansas, its likely invasion (see Strayer 1991) should be considered a threat to Kansas mussels. Such an invasion will likely compound efforts to restore the target mussel species in the near future.

9.1. Implement a nonindigenous species management plan (NSMP) for Kansas.

9.1.1. Provide input to the NSMP to educate the public about zebra mussels. The public needs to be aware of zebra mussels and how to prevent their spread into Kansas.

9.1.2. Provide input to the NSMP to develop a risk assessment model (see Schneider *et al.* 1998) for the potential spread of zebra mussels in Kansas. This information would aid in the prioritization of sites for relocation efforts and habitat restoration.

9.1.3. Provide input to the NSMP to develop guidelines and thresholds for mussel rescue efforts. Develop a protocol to determine when a population is at serious risk from zebra mussels. This task would develop procedures for the removal of native mussels from contaminated habitats to suitable relocation sites. The identification of potential quarantine habitats and facilities would be dictated by Task 9.1.2 and USFWS guidelines for protecting the genetic integrity of aquatic mollusks (Butler 1998).

9.1.4. Provide input to the NSMP to develop a protocol for future monitoring of zebra mussels.

10. Develop and implement an educational program about Kansas' freshwater mussels and their recovery. The public's interest and support of freshwater mussels and watershed stewardship are essential for the recovery of these species and their habitat.

    10.1. Establish educational stream sites by acquiring access to streams through the use of state income tax incentives. A landowner of an educational stream site would receive state income tax credit equal to the amount of property tax for acreage on and near the learning site, land used for accessing the site, and maintenance of access roads.

    10.2. Compile and distribute mussel-related educational materials. Specific learning materials might include a pictorial presentation of Kansas' mussels, educational mussel displays, and a Kansas mussel identification field guide with an illustrated, dichotomous key.

    10.3. Develop a slide and/or video presentation that describes the mussel recovery plan and what it will mean to the public. The slide/video presentation would be targeted to landowners to inform them of the recovery plan. The presentation would provide information about threatened and endangered mussels in southeast Kansas, and would outline conservation programs pertinent to the recovery plan, especially the state income tax incentive program. It should prove to be a useful tool for District Biologists and other KDWP personnel when informing the public about the recovery plan at social gatherings, such as County Conservation District meetings and banquets.

    10.4. Develop and publish an interactive Internet web site about the recovery plan and watershed stewardship. The web site would provide specific information about the recovery plan, including an online version in Portable Document Format (PDF), and would serve as a means to disseminate progress and success of recovery tasks. The web site would also provide in-depth information about state income tax incentives and conservation programs currently available to landowners, and would provide online inquiry forms, email and mailing addresses, phone numbers, links to other pertinent web sites (*e.g*. NRCS and USFWS web sites), and a list of frequently asked questions. In addition, the site would list case studies that identify and summarize successful habitat restoration and preservation projects related to this recovery plan, and provide a way to commend landowners that have participated in the recovery plan.

    10.5. Create an automated toll-free phone hotline dedicated to provide information about the recovery plan and the state income tax incentive program.

    10.6. Host meetings or workshops to educate and train aquatic resource managers and others about Kansas mussels and efforts to restore them. These workshops would include paper

presentations, updates regarding recovery efforts, and training (*e.g*. mussel identification, habitat assessments, and mussel sampling). Workshops would be similar to previous mussel meetings hosted by KDWP.

10.7. Continue to publish a newsletter about freshwater mussels, research, and progress of the recovery plan. A newsletter called the Kansas Pearly Mussel Newsline, which is targeted towards persons interested in the conservation of freshwater mussels in Kansas, has been published by KDWP on an occasional basis since 1997.

10.8. Develop a video presentation about impacts to stream habitats from instream gravel dredging and other channel modifications.

11. Reevaluate recovery criteria and tasks once every five years, and recommend appropriate amendments. The recovery plan must be periodically reevaluated to determine if recovery objectives are being met.

12. Utilize experts to help implement the recovery plan. Persons with aquatic and other pertinent expertise from such affiliations as KDWP, other governmental resource agencies, and academia should be consulted to help review research proposals, evaluate recovery projects, and recommend amendments to the recovery plan as recovery tasks are completed and as new species information is gathered. KDWP may form technical committees to address such concerns as riparian stabilization projects.

IV. IMPLEMENTATION SCHEDULE

General Ranking Categories.—Actions necessary to recover the four targeted mussel species are ranked in three categories:

Priority 1 – an action that must be taken to prevent a species from irreversible decline or extirpation.

Priority 2 – an action that must be taken to prevent a further decline in species abundance/range, or other negative impacts to a species short of extirpation.

Priority 3 – all other actions necessary to meet recovery objectives.

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
1	1.1.1.1	Offer state income tax credits to landowners who protect and/or restore riparian habitat.	TBD	**TBD**						
1	1.1.1.2	Provide tax incentives for practices that reduce non-point source pollution.	TBD	**TBD**						
2	1.1.1.3	Offer state income tax credits to landowners who participate in instream and stream channel rehabilitation projects.	TBD	**TBD**						
2	1.1.1.3.1	Determine priority stream reaches and sites for instream and stream bank restoration projects.	1	**1.0**	1.0					
2	1.1.1.3.2	Review instream and stream bank restoration projects.	1	**1.0**	1.0					
2	1.1.1.4	Offer state income tax credits to landowners who grant stream access for research purposes.	TBD	**TBD**						
3	1.1.1.5	Provide tax incentives for non-mandated improvements to rural sewer systems.	TBD	**TBD**						
1	1.1.2	Promote state and federal conservation programs that will rehabilitate watersheds.	ongoing	**TBD**						Administrative costs only.
3	1.1.3	Provide safe harbor agreements for participants of the recovery plan.	TBD	**TBD**						

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
1	1.2	Identify areas of concentrated land use, and investigate ways to mitigate water quality concerns.	TBD	**TBD**						
1	1.3	Develop partnerships with other governmental agencies, private organizations, and industries to identify and assess projects that will affect freshwater mussels.	TBD	**TBD**						
1	1.4	Integrate mussel die-off response needs with existing fish kill investigative procedures.	1	**1.5**	1.5					
1	1.5	Solicit expertise and funding for the four target species.	TBD	**TBD**						
1	1.6	Utilize existing legislation and regulations to protect species and habitat	ongoing	**TBD**						Administrative costs only.
1	2.1	Develop a georeferenced database of mussel distributional data.	1	**15.0**	15.0					
1	2.2	Incorporate mussel distributional data as a resource element coverage in a GIS.	1	**4.0**		4.0				
1	2.3	Update distributional data with additional sampling in unsurveyed stream reaches.	1	**10.0**			10.0			
1	3.1.1	Determine spawning/gravidity periods and optimal fish hosts for the target species.	1	**4.0**	4.0					

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
2	3.1.2	Conduct fish surveys in the upper Osage River system.	1	**14.0**	14.0					
1	3.1.3	Survey fishes at proposed reintroduction sites.	1	**2.0**		1.0				
1	3.2	Determine population demographics of each of the target species.	2	**8.0**	4.0	4.0				
2	3.3.1	Conduct habitat and nutritional studies, with emphasis on the juvenile life stage.	1	**5.0**	5.0					
2	3.3.2	Evaluate the sensitivity of mussels to physiochemical variables of primary and secondary concern (KDHE).	1	**5.0**		5.0				
2	4.1	Evaluate instream habitat in priority stream stretches using on-site habitat measurements.	2	**20.0**	10.0	10.0				
2	4.2	Assess riparian and stream habitats using remote sensing.	2	**6.0**		3.0	3.0			
2	4.3	Develop environmental instream flow requirements, and make recommendations to the USACE and KWO.	1	**4.0**		4.0				
1	4.4	Monitor the lower Marais des Cygnes R. during high water-use demand periods to ensure that adequate flows are maintained	continual	**TBD**						Partner with U.S. Fish and Wildlife Service.

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
2	5	Study the impact to mussels from traditional wastewater disinfectants, and investigate the potential of WTPs to use alternative disinfectant methods.	1	**10.0**		10.0				
2	6	Work with appropriate agencies and Legislative Committees to develop guidelines for mining instream gravel and sand.	TBD	**TBD**						
1	7.1	Establish experimental population (EP) boundaries for future reintroduction projects.	TBD	**TBD**						Administrative costs only.
1	7.2	Establish priority sites for reintroduction/augmentation projects.	TBD	**TBD**						Administrative costs only.
1	7.3.1	Initiate a pilot reintroduction project using juvenile mussels.	3	**15.0**			5.0	5.0	5.0	
1	7.3.2	Initiate a reintroduction and augmentation project by releasing fish infected with glochidia.	3	**6.0**			2.0	2.0	2.0	
1	8.1.1	Initiate extensive qualitative survey of mussels in the upper Osage River system.	2	**25.0**	12.5	12.5				
1	8.1.2	Establish quantitative sampling sites in the Marais des Cygnes and Marmaton rivers and in Pottawatomie Creek.	continual	**6.0**			2.0	2.0	2.0	FY05 = Marais de Cygnes R. FY06 = Marmaton R. FY07 = Pottawatomie Cr.

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
2	8.1.3	Monitor mussel populations at reintroduction/augmentation sites.	continual	**9.0**			3.0	3.0	3.0	Will extend beyond the 5-year implementation schedule.
2	8.2	Reevaluate streams for mussels at no less than 10-year intervals.	continual	**N/A**						Extends beyond the 5-year implementation schedule.
3	9.1.1	Provide input to the nonindigenous species task force (NSMP) to educate the public about zebra mussels.	TBD	**TBD**						
3	9.1.2	Provide input to the NSMP to develop a predictive model for the spread and impact of zebra mussels in Kansas.	TBD	**TBD**						
3	9.1.3	Provide input to the NSMP to develop guidelines and thresholds for mussel rescue efforts.	TBD	**TBD**						
3	9.1.4	Provide input to the NSMP to develop a protocol for future monitoring of zebra mussels, assuming zebra mussels become established in Kansas.	TBD	**TBD**						
3	10.1	Establish educational stream sites, using tax credit incentives.	TBD	**TBD**						
3	10.2	Compile and distribute educational learning materials related to watershed stewardship and freshwater mussels.	continual	**1.25**	0.25	0.25	0.25	0.25	0.25	

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
3	10.3	Develop a slide and/or video presentation that describes the mussel recovery plan.	1	**1.5**		1.5				
3	10.4	Publish a web page that informs the public about the mussel recovery plan and state and federal watershed stewardship assistance programs.	continual	**1.5**	0.5	0.25	0.25	0.25	0.25	
3	10.5	Create an automated toll-free phone hotline dedicated to provide information about the mussel recovery plan and state income tax incentive program.	continual	**1.25**	0.25	0.25	0.25	0.25	0.25	
3	10.6	Host meetings or workshops to educate and train resource managers and other interested parties about Kansas mussels and efforts to recover them.	ongoing	**2.5**	0.5	0.5	0.5	0.5	0.5	
3	10.7	Continue to publish a newsletter to provide information about Kansas mussels, research, and progress of the recovery plan.	ongoing	**1.25**	0.25	0.25	0.25	0.25	0.25	
3	10.8	Develop a video presentation about the negative impacts to stream habitats from instream gravel mining and other channel modifications.	1	**2.0**	2.0					

Implementation schedule for the four target mussel species in the upper Osage River system of east-central Kansas. Task numbers correspond with those in Section III—C.

Priority Number	Task No.	Task Description	Task Duration	Cost Estimate (in $1,000 units)						Comments/Notes
				Total Costs	FY03	FY04	FY05	FY06	FY07	
3	11	Reevaluate recovery criteria once every five years.	continual	**TBD**						Administrative costs only.
1	12	Utilize experts to help implement the recovery plan.	continual	**TBD**						Administrative costs only.

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APPENDIX A. ***List of the Unionoidea documented from the Osage River system.***

	State status		Federal	Global
	Kansas	Missouri	status	rank
Margaritiferidae				
Cumberlandia monodonta - spectaclecase	X	S3	C2	G2G3
Unionidae				
Actinonaias ligamentina - mucket	E			G5
Alasmidonta marginata - elktoe	E	S2	C2	G4
Alasmidonta viridis - slippershell mussel	X			G4G5
Amblema plicata - threeridge				G5
Anodonta suborbiculata - flat floater	E	S2		G5
Arcidens confragosus - rock pocketbook	T	S3		G4
Cyclonaias tuberculata - purple wartyback				G5
Ellipsaria lineolata - butterfly	T			G4
Elliptio crassidens - elephantear	---	S1		G5
Elliptio dilatata - spike	SINC			G5
Epioblasma triquetra - snuffbox	X	S1	C2	G3
Fusconaia ebena - ebonyshell	---	S1, E		G4G5
Fusconaia flava - Wabash pigtoe	SINC			G5
Fusconaia ozarkensis - Ozark pigtoe				G3
Lampsilis abrupta - pink mucket	---	S2, E	E	G2
Lampsilis cardium - plain pocketbook				G5
Lampsilis reeviana brittsi - northern broken-ray	---			G3[1]
Lampsilis siliquoidea - fatmucket	SINC			G5
Lampsilis teres - yellow sandshell	SINC			G5
Lasmigona complanata - white heelsplitter				G5
Lasmigona costata - flutedshell	T			G5
Leptodea fragilis - fragile papershell				G5
Leptodea leptodon - scaleshell	---	S2	PE	G1
Ligumia recta - black sandshell	X			G5
Ligumia subrostrata - pondmussel				G4G5
Megalonaias nervosa - washboard	SINC			G5
Obliquaria reflexa - threehorn wartyback				G5
Obovaria olivaria - hickorynut	X	S2S3		G4
Pleurobema sintoxia - round pigtoe	SINC			G4
Potamilus alatus - pink heelsplitter				G5
Potamilus ohiensis - pink papershell				G5
Ptychobranchus occidentalis - Ouachita kidneyshell	T	S2S3	C2	G3G4
Pyganodon grandis - giant floater				G5
Quadrula fragosa - winged mapleleaf	X	X, E	E	G1
Quadrula metanevra - monkeyface				G4
Quadrula nodulata - wartyback	SINC	S3		G4
Quadrula pustulosa - pimpleback				G5
Quadrula quadrula - mapleleaf				G5
Strophitus undulatus - creeper	SINC			G5
Toxolasma parvus - lilliput				G5
Tritogonia verrucosa - pistolgrip				G4
Truncilla donaciformis - fawnsfoot	SINC			G5
Truncilla truncata - deertoe	SINC			G5
Uniomerus tetralasmus - pondhorn				G4
Utterbackia imbecillis - paper pondshell				G5
Venustaconcha ellipsiformis - ellipse	E			G3G4

Appendix B. ***Worksheet to determine priority HUC-11 (11-digit hydrologic unit code) watersheds and sites. Numbers in parentheses represent an arbitrary point score.***

HUC-11 Watershed Designation

1. **Number of target mussel species with a historic presence[1] in watershed:**
   - ☐ none (**0**) ☐ two (**2**) ☐ four (**4**)
   - ☐ one (**1**) ☐ three (**3**)
2. **Number of extant target mussel species in watershed:**
   - ☐ none (**0**) ☐ two (**2**) ☐ four (**4**)
   - ☐ one (**1**) ☐ three (**3**)
3. **Number of extant state-listed mussels in watershed:**
   - ☐ none (**0**) ☐ 4-6 (**2**) ☐ >9 (**4**)
   - ☐ 1-3 (**1**) ☐ 7-9 (**3**)
4. **Overall species richness of extant mussels in watershed:**
   - ☐ 0-3 (**0**) ☐ 8-12 (**2**) ☐ >17 (**4**)
   - ☐ 4-7 (**1**) ☐ 13-17 (**3**)

Total Points _____

Site Designation

1. **Proximity to stream:**
   - **a.** ☐ on property (**4**) - *go to **2***
   - **b.** ☐ not on property but within 100 year flood zone (**0**) - *go to **2**, items **b** or **c***
   - **c.** ☐ upland site (**0**) - ***stop***
2. **Proximity to extant mussel populations:**
   - **a.** ☐ on property (**4**)
   - **b.** ☐ upstream (**2**)
   - **c.** ☐ downstream (**1**)
3. **Historical presence of target species:**
   - ☐ Yes (**4**) ☐ No (**0**)
4. **Presence of extant target species:**
   - ☐ none (**0**) ☐ two (**4**) ☐ four (**8**)
   - ☐ one (**2**) ☐ three (**6**)
5. **Presence of other state-listed mussels:**
   - ☐ Yes (**2**) ☐ No (**0**)
6. **Overall species richness of extant mussels:**
   - ☐ none (**0**) ☐ 6-10 (**2**) ☐ >15 (**4**)
   - ☐ 1-5 (**1**) ☐ 11-15 (**3**)

Total Points _____

[1] Species records for each HUC-11 watershed are not necessary for this category, provided there is documentation of a species in both upstream and downstream reaches of a stream that borders or transects the watershed.

Appendix C. *Eligibility criteria for riparian buffers along perennial streams for the state income tax incentive program.*

Riparian buffers must be at least 75 feet in width. Buffers will be broken into three management zones: streamside (Zone 1), middle (Zone 2), and outer (Zone 3). All buffers entered into a recovery agreement must consist of zones 1 and 2 regardless of stream size; the outer zone is optional. Property tax credit will be based on the amount of land from the middle of stream to the outer limits of either Zone 2 or Zone 3.

Management Zone Criteria:

Streamside Zone (Zone 1): Begins at the normal full bank water line (or from the top of steep, cut banks) to a width of 15 feet measured perpendicular from the edge of stream. Logging will not be allowed within the Streamside Zone. Grazing will also be prohibited along streams with a Strahler stream order classification greater than 1. However, grazing strategies that minimize riparian damage along smaller perennial and intermittent streams may be allowed in special circumstances. Dominant vegetation should be composed of native trees and associated understory plants and/or native grasses and forbs. Establishment of native trees will be required for property that is presently farmed within this zone.

Middle Zone (Zone 2): Begins from the outer edge of Zone 1 and occupies a minimum width of 60 feet. Predominant vegetation should be native trees and/or native grasses and forbs. Although grazing restrictions will mirror Zone 1, management for wildlife, aesthetics, and timber will be allowed as long as buffer objectives are not compromised[1]. Native trees and/or native grasses and forbs will be allowed for buffer plantings on land presently cropped.

Outer Zone (Zone 3): Begins from the outer edge of Zone 2 and occupies an area encompassing up to 50 percent of the 100-year floodplain. Acceptable vegetation will include native trees and associated understory plants and/or native grasses and forbs. Management for wildlife, aesthetics, and timber, as well as limited haying and grazing will be allowed in this zone[1]. Inclusion of Zone 3 into a recovery plan agreement will be optional, except where natural riparian buffers presently extend beyond 75 feet. For newly created buffers, the shape of a buffer may be squared or straightened; however, the narrowest portion of a riparian buffer must not be less than the combined minimum widths of zones 1 and 2.

[1] Additional management restrictions may apply for lands signed into other conservation programs. In the case of CP22 buffers, the harvest of timber resources and grazing is prohibited within all three management zones for the duration of CRP-1 (refer to NRCS Conservation Practice Standard Code 391A for riparian forest buffer specifications).

Appendix D. *Guidelines for maintaining genetic integrity for propagated freshwater mussels.*

1) Seed source – in order of decreasing importance:
   a) Brood stock from the recipient stream metapopulation;
   b) Brood stock from another metapopulation in the same stream basin;
   c) Brood stock from another metapopulation in an adjacent stream basin in the same physiographic province;
   d) Brood stock from another metapopulation in an adjacent stream basin in an adjacent physiographic province;
   e) Brood stock from the only metapopulation with sufficient adults to provide progeny.

2) Reduce homozygosity by maximizing brood stock numbers.

Taken from USFWS draft guidelines for maintaining genetic integrity in translocation efforts for aquatic mollusks (Butler 1998).

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