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RECENT MONITORING OF THE FRESHWATER MOLLUSKS OF KINNICONICK CREEK, KENTUCKY, WITH COMMENTS ON POTENTIAL THREATS

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ABSTRACT

This study was conducted to gain a better understanding of the current status of freshwater mollusks in the mainstem of Kinniconick Creek, a small tributary to the Ohio River. Qualitative and quantitative sampling documented 17 species of freshwater mussels and 8 species of freshwater gastropods from mainstem Kinniconick Creek. Declines in freshwater mussel species richness have been observed at several sites since 1983 as well as declines in densities. I discuss potential threats to the mussel fauna posed by excessive particle movement from historical channel alteration, human perturbation, and from changes in precipitation patterns.

KEY WORDS Unionidae, gastropods, snails, Ohio River drainage, drought, monitoring

INTRODUCTION

The freshwater mussel fauna (Mollusca: Bivalvia: Unionidae) of the southeastern United States has undergone dramatic changes as compared to pre-European colonization (Haag, 2009). In Kentucky, declines of freshwater mussels have been attributed to impoundments (Cicerello & Laudermilk, 1997; Sickel & Chandler, 1996), mineral extraction (Anderson et al., 1991; Warren & Haag, 2005) as well as non-point pollution (Houp, 1993). Another mollusk group that has experienced similar impacts, freshwater snails (Mollusca: Gastropoda), has one of the highest imperilment rates of any animal in the United States (Johnson et al., in prep; Neves et al., 1997).

I examined historical and contemporary mussel fauna of Kinniconick Creek in northeastern Kentucky. Kinniconick Creek is a direct tributary to the Ohio River. The stream was systematically inventoried by Warren et al. (1984). Subsequently, the mussel populations have been monitored by the Kentucky State Nature Preserves Commission (KSNPC) which includes quantitative sampling at one site in 1990. No published literature exists on the freshwater gastropod fauna of Kinniconick Creek.

Study Area

Kinniconick Creek drains 517 km2 in Lewis County, Kentucky (Figure 1). The stream has been identified as an aquatic biodiversity hotspot in Kentucky (Cicerello & Abernathy, 2004), and the mainstem has been designated a Reference and Exceptional Value reach (KY DOW, 2008). Much of the watershed is underlain by Mississippian-age oil shales as well as sandstones (Jacobs & Jones, 2004). Lower sections of Kinniconick Creek are underlain with Quaternary alluvium primarily derived from upland sources (Warren et al., 1984), while headwater areas are underlain with Devonian oil shales and limestone (Jacobs & Jones, 2004).

Land use is a mixture of agricultural fields along the floodplains with forest blocks into the uplands. Low density residential development is present throughout the watershed. Local landowners mentioned that in the 1950s, much of the upper portion of Kinniconick Creek was straightened and moved to the valley wall in order to increase farming production in the floodplain. This has resulted in the mobilization of large amounts of material from upland portions of Kinniconick Creek. Upper reaches of Kinniconick Creek are characterized by unstable banks and poor streambed conditions indicative of historical modifications.

METHODS

Qualitative Sampling - Mussels

In 2007 and 2008, I conducted qualitative sampling at fifteen sites (Figure 1) that have been examined in a prior study (Warren et al., 1984). While I examined the same reaches, the exact search areas from previous studies were unknown. Snorkeling, tactile searches, and

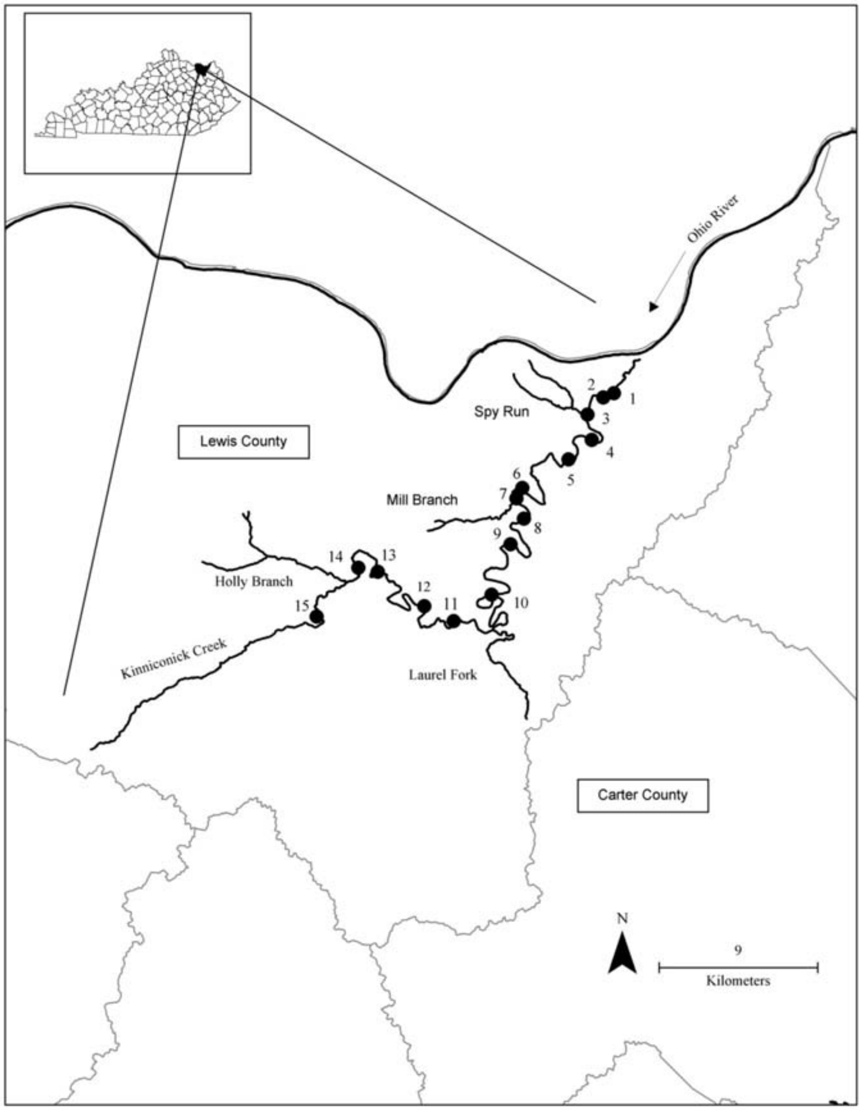

FIGURE 1
Study area and locations of sampling sites. The direction of flow of the Ohio River is indicated by the arrow.

visual searching were used for each site. I constructed a diminishing returns curve for each site to determine when adequate search effort had been expended (Dunn, 2000; Miller & Payne, 1993). To develop the curve, live and recently fresh dead (still containing fresh tissue) mussels were identified and enumerated at 10, 20, 40, and 60 individual intervals. A total of 28.6 person hours were spent in the qualitative sampling phase, with a mean of 1.9 person hours per site. Although exact sampling times of site visits from previous studies are not known, they approximate a minimum of 1 person hour per visit (R. Cicerello, retired KSNPC, per comm. 2007). I visited all sites between May and October; visibility was generally excellent during the study due to drought conditions.

I also examined records from recent sampling efforts at specific sites by KSNPC prior to this study (Table 1). Notable in the mollusk fauna of Kinniconick Creek is *Epioblasma triquetra* (Rafinesque, 1820) (Snuffbox), which has been proposed for listing as an Endangered Species by the United States Fish and Wildlife Service (USFWS, 2010). Additionally, *Simpsonaias ambigua* (Say, 1825) (Salamander Mussel) and *Villosa lienosa* (Conrad, 1834) (Little Spectaclecase) are listed as rare in Kentucky (KSNPC, 2010).

Quantitative Sampling - Mussels

To evaluate trends in demography, quantitative sampling was conducted at one site (the confluence of Mill Branch), which had also been sampled by KSNPC

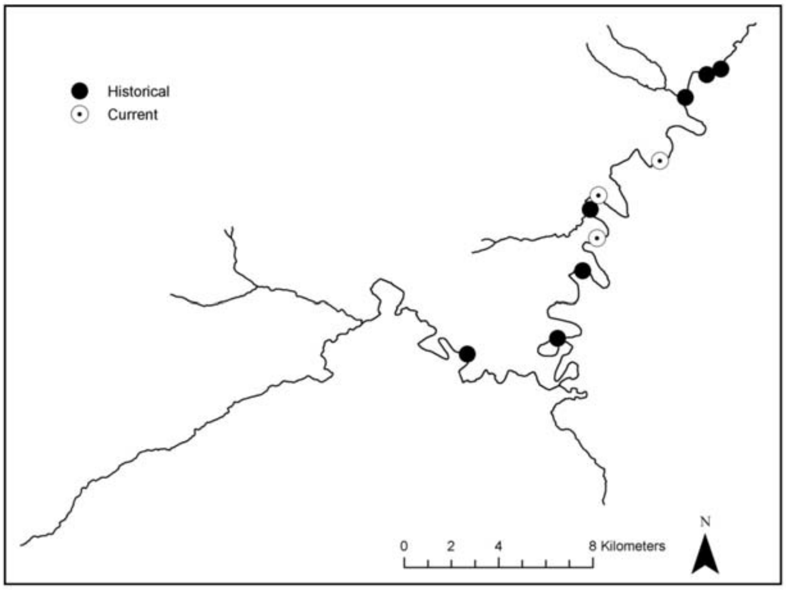

FIGURE 2
Historical versus current distribution of state-listed species in Kinniconick Creek.

in 1990. Prior to sampling, I snorkeled and flagged to delineate the densest portion of the mussel bed and an initial set of quadrats was also used to further delineate the area to focus the sampling. A systematic sampling design with three random starts (Strayer & Smith, 2003) implementing 1 m2 quadrats was used to conduct quantitative sampling over a 16 x 80 m area. A total of 26 quadrats were sampled, which was the number sampled by KSNPC in 1990. Substrates were excavated to a depth of 10-15 cm and sieved through a 1 cm mesh screen. Shells of freshwater mussels collected during this study have been deposited at the Ohio State University Museum of Biological Diversity, Columbus.

Freshwater Snail Sampling

Sampling for freshwater snails was opportunistic and involved collection of available microhabitats at sites after mussel sampling had been completed. The goal was to gather assemblage data on freshwater snails. A hand sieve was used to examine loose substrates such as woody debris or loose sand; other collections were made by hand. Snails were preserved in the field in 70% ethanol and retained for lab identification. References by Basch (1963), Jokinen (1992), Burch (1989), and Wu et al. (1997) were primarily used to confirm specimen identifications of freshwater snails. Voucher specimens are retained at the Kentucky State Nature Preserves Commission in Frankfort.

Taxonomy

Taxonomy generally follows Turgeon et al. (1998) with a few exceptions. *Laevapex* taxonomy follows Walther et al. (2006). *Physa* taxonomy follows Dillon et al. (2002). *Quadrula* taxonomy follows Serb et al. (2003).

Statistical Analyses

To analyze statistical differences in species richness between previous studies and this study, a 2-way Student t-test was conducted. All tests were conducted using Systat software (Version 11) at the 95% level of confidence and screened for normality prior to testing.

RESULTS

I encountered seventeen species and 678 freshwater mussels during this study (Table 2). When comparing the data from the current study to that from 1983, a species richness decline of 50% was observed at 4 sites, with the average richness value declining by 2.2 species per site. Differences in species richness from previous studies were not significantly different ($p > 0.05$). The presence of rare mussel species (Snuffbox, Salamander Mussel, and Little Spectaclecase) all exhibited a dramatic range reduction, from 9 sites occupied historically to 3 sites currently (Figure 2). There were slight increases in species richness at sites 9 and 10 (increased from 7 documented species to 9 species). Four mussels previously documented from either live specimens or shell remains, *Leptodea fragilis* (Rafinesque, 1820), *Ligumia recta* (Lamarck, 1819), *Pleurobema sintoxia* (Rafinesque, 1820), and *Truncilla truncata* Rafinesque, 1820, were not observed during this study. As with the previous study, species richness was low in the uppermost sites and reached the highest diversity in intermediate reaches. Further, the data show a reduction of freshwater mussel species from lower portion of the stream. The exotic Asiatic Clam, *Corbicula fluminea* (Müller, 1774), was present at all sites.

Quantitative sampling at Site 7 showed a statistically significant decline (3.42 ± 1 mussels/m2 in 1990 versus 0.4 ± 0.23; $p < 0.05$, standard error = 0.119) in density as well as species richness (from 11 to 5 species). In taking the exact same number of quadrats as previous sampling in 1990, the precision of mean estimate was 60%. Because such low densities were observed in 2007-2008, much more quadrat sampling (approximately double the number sampled here) would have been required to approach the 25% precision of the mean value of the 1990 dataset.

Eight species of freshwater snails were located either live or from shell materials (Table 3). The snail fauna did not include any state species of conservation concern. The most common species across all sites were *Helisoma anceps* (Menke, 1830) and *Pleurocera acuta* Rafinesque, 1824. The three upstream most sites supported only pulmonates. Pleurocerids were regularly distributed near the mouth upstream to site 12. Species richness tended to be highest at sites which exhibited the greatest habitat complexity, particularly the presence of floodplains, depositional areas, backwaters, and mixed woody debris. At sites where sedimentation was heavy, snails were typically located only on margins or the undersides of larger rocks.

DISCUSSION

A diverse mussel community remains in Kinniconick Creek although this study suggests some declines in mussel site occupancy and density. Three state-listed mussel species originally reported by Warren et al. (1984) remain extant at a reduced number of sites. Despite the findings of the qualitative phase of the study, it is difficult to evaluate if an actual decline has occurred due to the low statistical power of the sampling methods used in this study (Strayer, 1999a). Metcalfe-Smith et al. (2000) suggest more than 4.5 person-hours is necessary for rare species detection.

Quantitative sampling at Site 7 revealed a pattern of decline in both density and species richness of freshwater mussel. Because the data revealed a variance to mean ratio of 1, the mussels at this site were essentially spatially randomly distributed (Downing & Downing, 1991; Smith, 2006). Furthermore, no juveniles were detected of any species at the quantitative sampling site, which suggests that recruitment may be limited in Kinniconick Creek.

This study showed overall low numbers of freshwater snails in terms of density and species richness. Kinniconick Creek is generally reduced to low-flow pools in mid-summer and as such, the aquatic gastropod assemblage is dominated by pulmonates, which are better adapted to lower dissolved oxygen environments (Lodge et al., 1987). *Pleurocera acuta*, which was regularly distributed across sites typically in very low numbers, occurs in larger densities in streams with higher dissolved oxygen and higher carbonate levels (Houp, 1970). Additionally, Johnson and Brown (1997) determined that adult pleurocerids of *Elimia semicarinata* (Say, 1829) (Pleuroceridae) in Kentucky preferred slower-flowing areas that provided flow refugia, whereas the opposite was true regarding juveniles.

In 2007, Kinniconick Creek was impacted by severe drought, and several sites were reduced to very shallow pools. There have been fourteen drought events in northeastern Kentucky since 1976 that are categorized as extreme drought on the Palmer Drought Severity Index (Palmer, 1965; Figure 3). Three of the drought events, between 1999 and 2007 exceeded -10 on the PDSI (with 2007 being the most severe drought in the basin since 1930). Conversely, the highest five years of extreme rain events on record have been observed since 1976 according to the PDSI, with the 2 highest rain events on record between 1989 and 2004. One serious cause of concern for many aquatic ecosystems is global climate change (Poff et al., 2002; Wrona et al., 2006). Global climate change is thought to threatenfreshwater mussels and fishes in small Nearctic and Palearctic streams (Haag & Warren, 2008; Hastie et al., 2003; Matthews & Marsh- Matthews, 2003). Golladay et al. (2004) and Haag and Warren (2008) measured precipitous declines of freshwater mussels as a result of a severe drought. An indirect stressor associated with low flow periods is recurring die-offs of Asiatic Clams (*Corbicula fluminea*) which are present throughout Kinniconick Creek. Mortality of Asiatic Clams due to decreased dissolved oxygen levels often result in pulses of ammonia (both in the water column and through porewater) which can act to further stress or cause mortality to native mussels (Cherry et al., 2005; Cooper et al., 2005). The interaction between drought periodicity and ammonia loading from Asian Clam turnover is an area that should receive further study.

Changes in substrate fractions towards greater amounts of fine sand with lower amounts of silt and organic components have been shown to promote higher biomass of Asiatic Clams (Cooper, 2007). Excessive sediment was noted as very heavy at several sites during the summer months. The sources for exces-

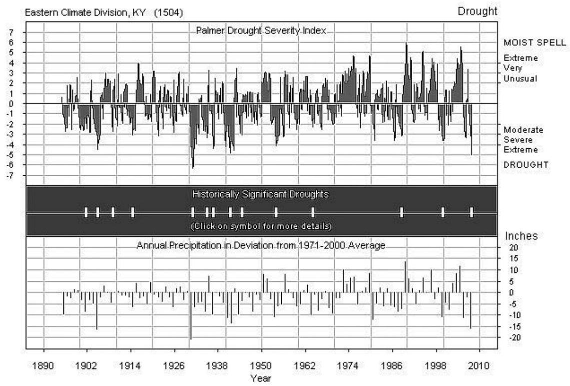

FIGURE 3

Drought and precipitation trends for eastern Kentucky. Graph is available for use at http://kyclim.wku.edu/graphlets/dsg.html.

sive sedimentation in Kinniconick Creek have not been specifically identified, but it likely arises from upland sources as a result of widespread watershed alterations. Headwater sites exhibited headcutting (deeply incised channels that were generally disconnected from the floodplain) which is promoting a condition of greater bed stress and excessive sediment supply. Landowners mentioned efforts in the 1940s and 1950s by the US Soil Service to promote channelization of streams to landowners, ostensibly to assist in crop production and reduce flooding. The aforementioned channelization of the headwater portions of the watershed is a known cause for lowered or disrupted water tables as well as a large contribution of upland sediments in Kentucky streams (A. Parola, University of Louisville, pers. comm., 2009). This particularly applies to substrates during high flow events, as modeled in larger rivers by Morales et al (2006). Virginia Spirea (*Spirea virginiana*), a Federally-Threatened shrub that utilizes cobble bars and stream banks for habitat, has declined over the long-term in several areas in Kinniconick Creek (D. White, KSNPC, pers. comm., 2009). Large woody debris (trees) entering the creek from upstream areas as a result of bank destabilization could be serving to scour the cobble bars that this species thrives on (A. Parola, pers. comm., 2009). The large-scale instability in stream banks and particle movement could be the source of observed declines as water quality is generally very good in Kinniconick Creek. It remains a very rural watershed with less of the influence of impacts typical of more urban areas (stormwater quality, increased impervious surface, etc).

One observation at the higher quality remaining sites in intermediate reaches was the presence of an adjacent area of flow accessible floodplain throughout at least one section of the site in conjunction with larger cobble substrates. Kinniconick Creek maintains a high degree of longitudinal connectivity which is likely an important factor in terms of host fish movement and the long-term maintenance of mussel beds (Newton et al., 2008). Enhanced floodplain connectivity would likely help reduce sheer stress on mussel habitats at the higher quality sites. Low sheer stress has been shown to be an important physical characteristic of robust mussel beds (Howard & Cuffey, 2003; Layzer & Madison, 1995; Peck, 2005; Strayer, 1999b).

Gravel mining for local road maintenance in Laurel Fork and McDowell Fork was observed in the early 1980s by Warren et al. (1984). Instream gravel mining has been reported by Hartfield (1993) as a causal factor in freshwater mussel declines as well as fishes (Cross et al., 1982). Instream mining can alter stream geomorphology, width to depth ratios and stream gradient (Meador & Layher, 1998; Roell, 1999) and result in channel scouring, incision (Kondolf, 1997) and headcutting (Hartfield, 1993; Meador & Layher, 1998). The nature of this activity in Kinniconick Creek requires further examination. It is possible that much of the local gravel extraction activity is focused on collecting deposits resulting from aforementioned watershed alterations that are being mobilized and redeposited during high flow events, instead of channel excavation and active mining of the stable portions of the channel (A. Parola, pers. comm., 2009). Finally, erosion resulting from all terrain vehicles (ATVs) along streambanks was seen at consecutive sites in the middle portions of the watershed. On one occasion, an individual was encountered riding an ATV directly through a drought-impacted shallow pool containing Snuffbox (*Epioblasma triquetra*) as well as two other state-listed mussel species.

In summary, decreases in overall unionid densities, decreases in site occupancy of rare species, several direct human disturbances to habitat, and potential changes in precipitation patterns are long-term considerations of the freshwater mussels in Kinniconick Creek. Several of these issues are affecting the mussel fauna of other small Ohio River basin streams as well (Fraley & Ahlstedt, 1999). As conservation efforts move forward to protect the remaining high-quality freshwater mussel populations in Kentucky, it will be important to consider the protection of remaining habitats in small watersheds such as the focus of this study, which are susceptible to chronic environmental changes.

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TABLE 1

Previous records from Kinniconick Creek. Numbers in columns refer to the total number of sites a given species has been previously reported.

	Warren et al. (1984)	KSNPC database records (from 1984 to 2007)
Amblema plicata (Say, 1817), Threeridge	2	1
Elliptio crassidens (Lamarck, 1819), Elephantear	1	0
Elliptio dilatata (Rafinesque, 1820), Spike	6	2
Epioblasma triquetra (Rafinesque, 1820) , Snuffbox	6	3
Fusconaia flava (Rafinesque, 1820) , Wabash Pigtoe	5	1
Lampsilis cardium Rafinesque, 1820, Plain Pocketbook	6	1
Lampsilis fasciola Rafinesque, 1820, Wavyrayed Lampmussel	2	0
Lampsilis siliquoidea (Barnes, 1823), Fatmucket	7	1
Lasmigona costata(Rafinesque, 1820), Flutedshell	2	1
Leptodea fragilis(Rafinesque, 1820), Fragile Papershell	1	1
Ligumia recta (Lamarck, 1819), Black Sandshell	0	1*
Pleurobema sintoxia(Rafinesque, 1820), Round Pigtoe	0	1
Potamilus alatus(Say, 1817), Pink Heelsplitter	3	1
Ptychobranchus fasciolaris (Rafinesque, 1820), Kidneyshell	7	2
Pyganodon grandis(Say, 1829), Giant Floater	2	0
Quadrula pustulosa(I. Lea, 1831), Pimpleback	2	0
Quadrula verrucosa (Rafinesque, 1820), Pistolgrip	4	2
Simpsonaias ambigua(Say, 1825), Salamander Mussel	3	0
Strophitus undulatus(Say, 1817), Creeper	4	1
Truncilla truncata Rafinesque, 1820, Deertoe	0	1
Villosa iris (I. Lea, 1829), Rainbow	3	2
Villosa lienosa(Conrad, 1834), Little Spectaclecase	4	3

* reported as weathered dead or relic shell only

TABLE 2

Summary of freshwater mussel observations in Kinniconick Creek by sampling station; species highlighted in bold are Listed as Special Concern, Threatened, or Endangered by Kentucky State Nature Preserves Commission. P = previously reported as live or fresh dead shell; C = present in current study as live or fresh dead.

Station Number	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15	
No. of person-hours (current study)	1		1.5		2		1		3.5		1		3		3.2		4		3		1.2		1		1.2		1		1	
	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C
Amblema plicata						X*			X	X						X		X	X	X										
Elliptio crassidens									X	X																				
Elliptio dilatata				X*	X	X*		X*	X	X			X	X	X	X	X	X	X	X										
Epioblasma triquetra			X						X				X		X		X	X*	X	X										
Fusconaia flava					X*	X			X	X			X	X	X	X		X	X	X										
Lampsilis cardium				X	X	X*			X	X			X	X	X	X	X	X		X	X									
Lampsilis fasciola					X				X							X		X												
Lampsilis siliquoidea					X				X	X			X		X	X	X	X	X	X			X	X						
Lasmigona costata									X						X					X										
Leptodea fragilis	X*								X																					
Ligumia recta													X*																	
Pleurobema sintoxia																			X											
Potamilus alatus									X						X	X	X	X												
P. fasciolaris					X	X*			X	X		X*	X	X	X	X	X	X	X	X	X		X							
Pyganodon grandis																					X		X	X						
Quadrula pustulosa									X						X															
Quadrula verrucosa													X	X	X	X	X	X	X	X										
Simpsonaias ambigua	X												X					X												
Strophitus undulatus									X	X			X						X				X	X						
Truncilla truncata									X																					
Villosa iris									X					X				X	X	X										
Villosa lienosa					X				X					X	X					X			X							
Total No of Spp – Live or Fresh Dead	1	0	1	1	6	1	0	0	17	8	0	0	9	7	11	9	7	11	10	11	3	0	5	3	0	0	0	0	0	0

* reported as weathered dead or relic shell only

TABLE 3

Freshwater gastropods observed during qualitative searches in Kinniconick Creek, Lewis County, KY in 2007-08. Numbers in top row refer to site numbers.

Order	Family	Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Architaenioglossa	Viviparidae	*Campeloma decisum* (Say, 1817)	X		X	X											
Neotaenioglossa	Pleuroceridae	*Pleurocera acuta* Rafinesque, 1831	X		X	X		X			X			X			
Basommatophora	Ancylidae	*Laevapex fuscus* (C.B. Adams, 1841)												X			
Basommatophora	Lymnaeidae	*Pseudosuccinea columella* (Say, 1817)						X									
Basommatophora	Physidae	*Physa acuta* Draparnaud, 1805														X	
Basommatophora	Physidae	*Physa gyrina* Say, 1821						X					X				
Basommatophora	Planorbidae	*Helisoma anceps* (Menke, 1830)			X			X					X	X	X	X	
Basommatophora	Planorbidae	*Micromenetus dilatatus (*Gould, 1841)			X			X							X	X	
Total			2	0	4	2	0	5	0	0	1	0	2	3	2	3	0