3-29-2017

A Reexamination The Freshwater Mussels (Family Unionidae) In Lower Big Walnut Creek

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29 March 2017

Submitted in partial fulfillment of the requirements

For graduation with Distinction

Advisor (Please print name)	Advisor’s Signature
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Acknowledgement

First, I would like to thank my research advisor, Dr. Michael Hoggarth, for giving me this opportunity and for the patience and excellent guidance he has provided me throughout this project. I would like to thank Dr. Kevin Svitana for serving as my second reader on this thesis project. I would like to thank Dr. Jeffrey Lehman for serving as my distinction representative. I would like to thank Dr. Kevin Svitana, Dr. Joan Esson, Nathan Hess, and Hayley Quinn for the patience and collaboration put forward to fully complete this thesis project. I would like to thank the Department of Biology and Earth Sciences, the Student Research Fund, and the Friends of Big Walnut Creek for funding this project. Lastly, I would like to thank my friends and family for all the support and encouragement they gave me throughout this project.

Abstract

Freshwater mussels (family Unionidae) have become increasingly rare as the threats to water quality, habitat quality, and other aquatic animals, which the mussels depend on, have increased. The absence of mussels can provide evidence that one of these factors is insufficient. Lower Big Walnut Creek (BWC) is known to support a diverse community of mussels but they are unevenly distributed throughout the creek with abundance, density, and richness being high in the upper section, very low in the midsection, and intermediate in the lower section. It has been suggested water quality nor symbiotic fish host communities are responsible for this uneven distribution. The purpose of this study was to understand if mussel communities today are still unevenly distributed, if there are any sign of recovery or change in the distribution, and if we could pinpoint the cause for the midsection decline. This study was done in conjunction with similar studies on the composition and chemistry of the sediments. Mussels were collected using the two phase survey methods of the Ohio Mussel Survey Protocol at nine sites throughout lower BWC. Current trends in mussel communities were analyzed using single factor ANOVA and student t-tests. A Pearson correlation analysis was used to analyze past vs. current trends. We found there is still a significant uneven distribution throughout the creek in abundance ($F_{[2,6]} = 10.31$, $p = 2.34 \times 10^{-5}$), density ($F_{[2,6]} = 8.49$, $p = 0.018$), and species richness ($F_{[2,6]} = 6.01$, $p = 0.037$), which compare favorably to a past study, with positive correlations in abundance ($r = 0.68$, $p = 0.043$), density ($r = 0.73$, $p = 0.024$), and species richness ($r = 0.71$, $p = 0.032$). However, our study constricted the impacted area upstream and found *Truncilla donasiformis* (an Ohio threatened species) had increased its range into the creek suggesting recovery is continuing. Sediment analyses are inconclusive at the time.

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Introduction

The family Unionidae contains the bivalve mollusks generally referred to as freshwater mussels. Freshwater mussels are easily identified by a number of anatomical features: they have two calcareous shells, or valves, that are connected dorsally by a hinge ligament, their shells are closed by adductor muscles, they have an umbo located anterior to the center of the shell, which may or may not be elevated, and they have a siphon in order for water to enter and leave the mussel (Fig 1a) (Watters et al., 2009). Their shells are made of three layers: the periostracum which is the outermost layer, the prismatic layer, which is the middle layer, and a pearly nacre which forms the interior layer of the shell (Carrol et al., 2006). On the inside of the mussels there is a soft bodied organism which includes gills used for respiration and capturing food, mantle flaps used to attract a host, which are not always present, and a foot used to move the mussel through the substrate and anchor the mussel (Fig 1b) (Cummings and Graf, 2010). The shell may present lateral teeth and/or pseudocardinal teeth, scars where muscles attach to the shell, and a pallial line (Fig 1c) (Williams et al., 2014).

As the name implies, freshwater mussels live in a variety of freshwater habitats including rivers, streams, and lakes. Many factors influence what makes a habitat suitable for mussels. Suitable habitats typically include the presence of shallow riffles along the edges of the habitat and away from deep, slow moving pools (Hoggarth and Grumney, 2016). Specifically, larval mussels, known as glochidia, are impacted by hydraulic conditions and fish host abundance in determining where they settle (Hastie et al., 2000: Schwalb et al., 2013). Juvenile mussels (no longer larvae because once glochidia leave their host they begin their free living stage) need the hyporheic zone to mature into adulthood (Hastie et al., 2000). Once settled, it is important for these juveniles to have a habitat with sediment that allows them to bury and good physicochemical conditions to continue to survive (Quinlan et al., 2015). As for adults, bed surface morpho-sedimentary characteristics, near-bed hydraulics, and surface water oxygen concentrations are the most important factors influencing their survival (Quinlan et al., 2015). It has been shown that catchment-scale abiotic variables including stream power and agriculture land use as well as water quality and physical barriers also influences mussel's habitat suitability (Pandolfo et al., 2016; Gillis et al., 2017).

Freshwater mussels have the capacity to live a long time (20-50 years) and produce many gametes (Reis and Araujo, 2016). During reproduction, the male mussels release sperm into the water after which the females draw this sperm in during filter feeding and then use this sperm to fertilize eggs moving toward the marsupia. The fertilized larvae will be held in the maternal mussel's gills (marsupia) where they grow and develop into a bivalve larvae called a glochidium. Glochidia (plural of glochidium) are parasitic and typically rely on fish as their host. When the maternal mussel releases these larvae, the glochidia will attach to the fish host's gills or fins. As the fish host carries them to a new location, the glochidia will develop into a juvenile mussel where they will drop off of the fish and settle to the bottom of the stream (Kat, 1984). Freshwater mussels are sedentary and they typically do not move once they have fallen off a fish host unless they are carried downstream with the waters current, floods, or drift displacement (Strayer, 1999: Irmscher, 2015). It is true that some species move more than others, but none would be considered highly mobile and so most mussels remain very close to where they dropped off their fish host. Wherever the mussel officially settles is where they will bury into the sediments and develop into adults. This process can take up to three years but once they are mature adults they are ready to reproduce and start the life cycle over (Reis and Araujo, 2016) (Fig 2).

Freshwater mussels are important to their ecosystems and provide many ecosystem services. These services include water purification during filter feeding which leads to improved water quality and clarity, nutrient cycling through depositing feces and pseudofeces, and energy transfer (Lummer et al., 2016). Mussels provide habitats, nutrient storage, and food to other organisms with their shells, tissue, and filtering of water (Klos et al., 2015: Vaughn et al., 2015). Furthermore, mussels potentially minimize effects of floods and waves, eliminate algal blooms, and play a role both bottom-up and top-down in the food chain as prey (Atkinson et al., 2014).

Unionids (a common name made from the shortening of their family name) have been studied intensely for the last 150 years and have been facing major declines for at least the last fifty years (NNMCC, 1997). Freshwater mussels have been determined to be one of the most endangered groups of organisms (NNMCC, 1997; Gillis et al., 2017). North America has the highest mussel diversity with about 300 different species alone (Bogan, 1993) however, it has been estimated that about 70 percent of these 300 species are threatened with many already listed as endangered or threatened and others in decline or already extinct (Bogan, 1993: NNMCC, 1997: Gillis et al., 2017). There are many causes for the declines mussels are facing today. Some of the direct impacts humans have had on mussels include using their shells as jewelry and the soft tissue of the mussel as meat for food (Watters et al., 2009). The indirect affects humans have had on mussels include our participation in pollution, heavy metal contaminants (including zinc, copper, and lead), construction, dredging, introduction of invasive species, and dams and impoundments (Roberts et al., 2008; Mochado et al., 2014; Besser et al., 2015). Other factors causing declines in mussel communities that could be due to humans or nature alone include declines in host fish populations, hydraulic modifications, and runoff (Shwalb et al., 2013; Fritts et al., 2015; Klos et al., 2015). With so many potential causes for mussel decline, it is very important to understand exactly which factor(s) is the cause of decline in a specific region in order to help conserve these organisms.

Aquatic organisms are impacted by (and therefore can detect impact on) water quality (generally thought of as water chemistry), habitat quality (including the presence and absence of a suitable habitat), and symbiosis (who else is present in the environment). Environmental quality refers to the properties and characteristics of an environment that are required for organism's survival. For aquatic animals this includes, but is not limited to, noise, water temperature, turbidity, and chemistry (Zipper et al., 2016). When studying effects water quality has on mussels several studies have found worsening water quality results in a decline in mussel abundance and distribution (Johnson et al., 2014; Zieritz, 2016; Zipper et al., 2016). However, when looking at lower Big Walnut Creek it was found that water quality had no correlation to the mussel community dynamics (OEPA, 2000; Ellenbogen and Hoggarth, 2015; Smoot and Hoggarth, 2016). This would suggest that water quality was supportive of the stream and the aquatic communities in the stream in order for survival to occur. Since environmental quality did not explain the trends in mussels found in lower Big Walnut Creek, symbiotic relationships was studied next.

Symbiosis refers to interactions between two organisms where either one, both, or neither benefits from the interactions. As mentioned above, freshwater mussels rely on fish host in the early stages of the mussel's life history. Specifically, a fish host is essential for larval transformation into juvenile mussels. In addition, attaching to a fish can transport the mussel to a new location within a stream. This allows for distribution throughout a system (Hastie et al., 2000; Schwalb et al., 2013). According to some studies, host fish was the primary factor influencing mussel's distribution (Hastie et al., 2000; Schwalb et al, 2013) where some studies found the host fish had no correlation to mussel distribution (Krebs et al., 2010). When looking at the fish communities in lower Big Walnut Creek, Smoot and Hoggarth (2016) found where mussel communities were low, fish host communities were abundant. This suggested the fish and mussel communities were not correlated and something else within the creek is responsible for the low mussel abundance in the mid-section of the creek (Smoot and Hoggarth, 2016). Once again, symbiosis was not found to explain the trends of mussel distribution, specifically in lower Big Walnut Creek.

Habitat quality is referred to as the ability of a specific habitat to provide appropriate conditions for individuals and populations to thrive and reproduce. This includes resource availability such as food, protection, finding a mate, predation, competition, and accessibility of these resources (Johnson, 2007). Specific to mussel communities, sediments are found to be one of the most vital aspects of a mussel's habitat to allow for survival and reproduction. Studies have found sediments having a limiting effect on mussel abundance and distribution, specifically larger sediments and higher concentrations of heavy metal contaminants and biochemical biomarkers (Appleton et al, 2001; Roberts et al., 2008; Allen and Vaughn, 2010; Mochado et al., 2014; Besser et al., 2015; Klos et al., 2015; Gillis et al., 2017). Since the sediment characteristics, both physical and chemical, in lower BWC have not yet been studied, the intent of the broader study, of which this was a part, was to do so. Overall, the study examined habitat quality and the effects sediments may have on mussel community dynamics.

The headwaters of Big Walnut Creek are in Morrow County, where the creek runs south through Delaware County and flows into Hoover Reservoir. Hoover Reservoir's dam and impoundment were created in 1955 to help supply the Columbus, Ohio area with a water resource (ODNR, 2016). Lower Big Walnut Creek watershed runs from Hoover Dam to the mouth of the creek (37.6 miles). From Hoover Dam the creek continues to flow south through Franklin County. Three main tributaries flow into BWC in this section: Rocky Fork Creek (RM 28.3), Alum Creek (RM 15.32), and Blacklick Creek (RM 15.33). The latter two enter BWC in Three Rivers MetroPark. BWC then continues to flow south into Pickaway County where it joins the Scioto River (Ellenbogen and Hoggarth, 2015). The integrity of lower Big Walnut Creek has been historically compromised not only by the Hoover Reservoir, but also by historical oil spills from Columbus International Airport, the tributary streams, Rickenbacker International Airport and Air Force Base, and by streamside development (OEPA, 2003; Friends of BWC, 2006; MORPC, 2012). As of 1994, about 70 percent of lower BWC's watershed was being used for human activity compared to the 82 percent in 2012 (Friends of BWC, 2006; MORPC, 2012). According to the Ohio Environmental Protection Agency (2003), these events have damaged the fish, macroinvertebrate, and mussel communities in lower BWC. While fish and macroinvertebrates have shown recovery, the mussels have not (OEPA, 2003; MORPC, 2012; Hoggarth and Grumney, 2016). Lower BWC once supported forty mussel species (Watters et al., 2009) while Hoggarth and Grumney (2016) found the creek to support only thirty-one mussel species in 2013. Hoggarth and Grumney (2016) described the distribution of these mussels to be unevenly distributed throughout the creek with the mid-section having much lower abundance and diversity than the rest of the creek. This led to the initial question of what eliminated the mussels from the midsection of this portion of the creek and if this fauna was recovering. As described above, this led to previous studies suggesting that both the habitat quality and symbiotic relationship do not correlate to the uneven distribution in the creek (Ellenbogen and Hoggarth, 2015; Smoot and Hoggarth, 2016).

The objective of this study was to refine Hoggarth and Grumney's (2016) mussel abundance and distribution results with three main goals. First, we planned to address the current trends throughout lower BWC in mussel abundance, mussel density, and species richness and then compare these results to the past study. If current mussel dynamics result in the same uneven distribution patterns throughout lower BWC, then we expected to see a positive correlation between the two studies' mussel community dynamics. Second, we addressed the potential recovery of mussel communities. If we found an increase in mussel abundance, density, and/or the presence of new mussel species, then this would have suggested the recovery potential of mussels was present and increasing. Lastly, the plan was to address the role sediments may have on mussel community distribution and abundance with the aid of two other research projects. If mussel community dynamics decrease where sediment structure and chemistry is unfavorable to mussels, then this would have suggested habitat quality is affecting mussel community dynamics and distribution.

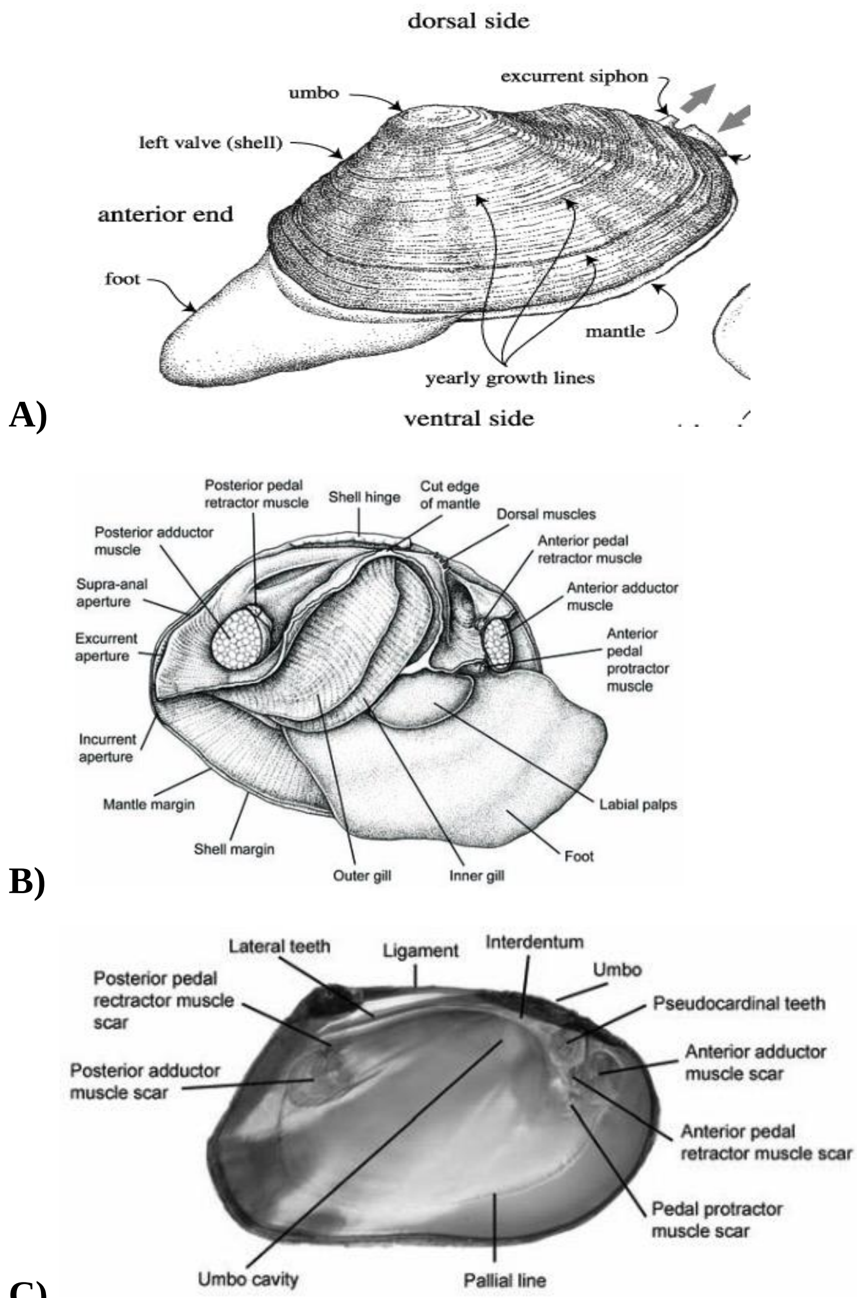


Figure 1: Anatomy of Unionids including (a) the exterior shell anatomy (http://oepos.ca.uky.edu/sites/oepos.ca.uky.edu/files/mussel.png), (b) the soft body anatomy (Williams et al., 2014, page 123), and (c) the interior shell anatomy with the soft-body removed (Williams et al., 2014, page 118).

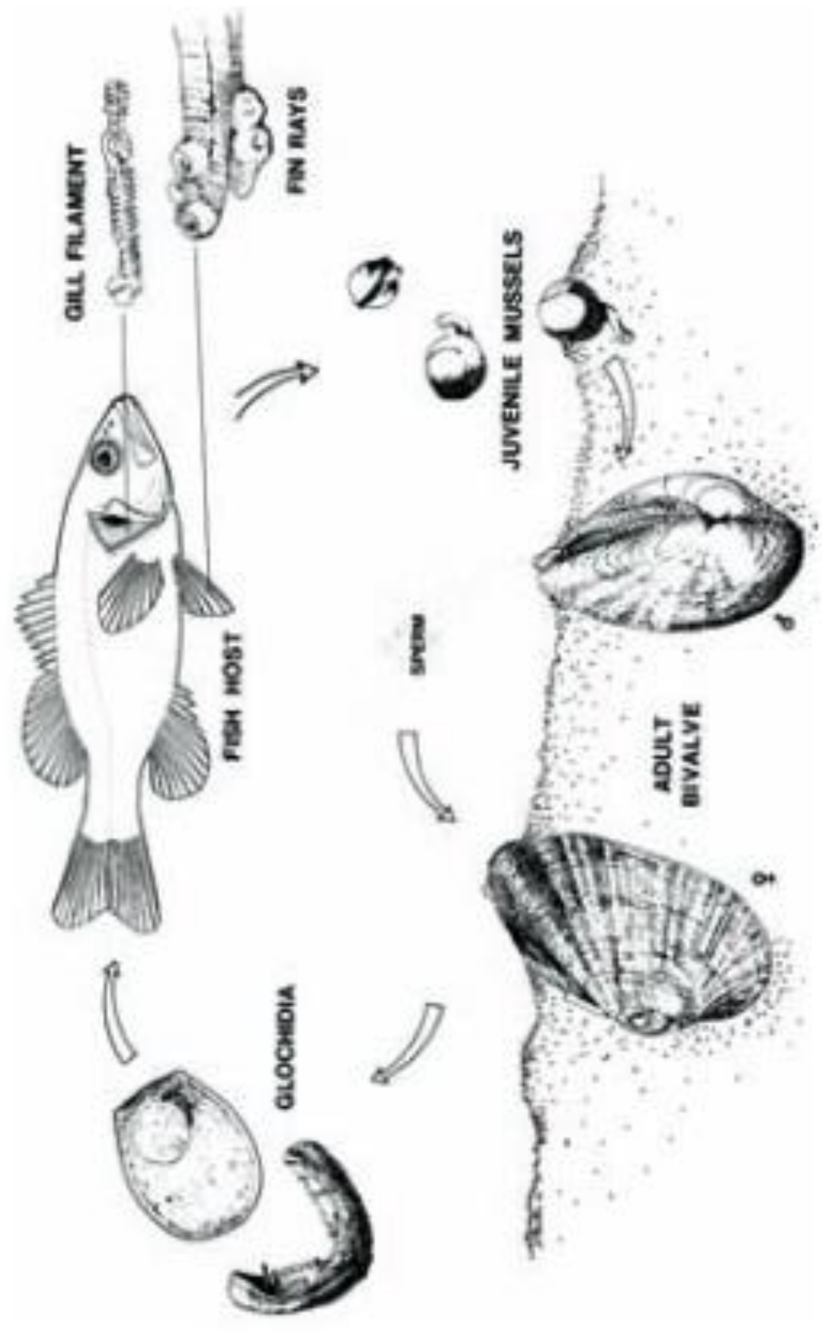


Figure 2: Life cycle of Unionids (Williams et al., 2014, page 79).

Materials & Methods

Location

Data collection occurred from 10 July 2016 to 27 September 2016 at nine locations on lower Big Walnut Creek in Ohio just downstream of Hoover Reservoir to its mouth at the Scioto River. These sites were previously sampled by Hoggarth and Grumney (2016). We resampled their sites 3, 8, 9, 11, 12, 13, 16, 18, and 20 (Table 1) (Fig 3). Throughout this paper the terminology upper, middle, and lower sections of lower Big Walnut Creek will be used frequently. The upper portion includes sites 3, 8, and 9. The middle portion of the creek includes sites 11, 12, and 13. Last, the lower portion of the creek includes sites 16, 18, and 20.

Field Work

The methodology used during the data collection followed the Ohio Mussel Survey Protocol (ODNR, 2016). Upon arrival at each site water temperature (℃) and conductivity (uS) were measured with a HACH sensION 5 Conductivity Meter, and turbidity (NTU) was measured using a HACH 2100P Turbidimeter. Once these data were recorded, a $100m^2$ cell was constructed in the study area. This was done with four ropes, previously marked in ten-meter intervals, held in place with stakes that were hammered into the creek floor. Once a cell was properly constructed, the two phase survey began. The phases were a times search phase (phase 1) and a quantitative phase (phase 2).

A phase 1 survey consisted of visual searches for mussels within a $100m^2$ cell. Visual searches consisted of moving cobble and woody debris, hand sweeping away sediments, and disturbing the top five centimeters of substrate. Aquascopes® were used to allow a clear and close inspection of the substrate and potential mussels. This survey was timed with an initial period of twenty minutes per cell followed by an additional thirty minutes per cell for a total initial effort of 0.5 minutes/m^2. When a mussel was collected it was identified, measured (length), and determined to be living, freshly dead (soft tissue present and no erosion of the shell), weathered (dead with noticeable erosion of the shell), or subfossil (dead with the internal/external shell faded to white). Only shells with both valves present were collected. One difference between our methods and those described in the Ohio Mussel Survey Protocol was if no mussels were found in the first twenty minutes of the timed search we still proceeded to do the additional thirty minutes instead of moving onto phase 2 and if we found no mussels in phase 1 at all we still proceeded to phase 2 as the protocol suggests. If no mussels were found in phase 1, the data recorded was written as “no mussels”, and the study proceeded to phase 2.

A phase 2 survey employed twenty ¼ m^2 quadrats within the 100m^2 cells in order to quantify mussel density within each cell. Excavating quadrats also allowed us to discover the presence of buried, juvenile, and/or rare species that may not have been seen in phase 1. At each location the twenty quadrats were randomly selected to avoid biased results employing the three-random sampling protocol of the Ohio Mussel Survey Protocol. This was done by selecting two of the three unique sets of twenty quadrats that were made with a random numbers generator. Once selected, the twenty quadrats were excavated (substrate was removed) to a depth of fifteen centimeters and placed into a dive bag and brought to the surface. Each substrate sample was then searched for mussels and non-native mollusks, specifically the Asiatic clam, *Corbicula fluminea*. The mussels found were measured and identified to species and then set aside to avoid recollection of the same individuals. These data recorded were used to determine species diversity and total mussel diversity and abundance. After phase 1 and phase 2 were completed in cell one, a new cell directly upstream of cell one was then created and the methodology was repeated. Once all phases were completed in both cells, the mussels collected were then placed back into the creek slightly upstream of where they were collected.

<u>*Statistical Analysis*</u>

Mussel Abundance

Mussel abundance was calculated as the total number of live and fresh dead mussels found per location site. The number of mussels per section (upper, middle, and lower) were averaged and then compared by using a single factor ANOVA. Student t-tests were then performed to determine which means, if any, were significantly different. Three different student t-tests were done including a comparison between the upper to middle, upper to lower, and middle to lower sections of the creek. A p-value of less than 0.05 was used to indicate a significant difference in the data suggesting the difference seen was not caused by chance but rather an outside factor.

Mussel abundance, past vs. present, was compared by using a Pearson correlation analysis where the R-value and p-value were obtained. An R-value greater than 0.5 would indicate a strong correlation between the data, an R-value of $0.3 < R < 0.5$ would indicate an intermediate correlation, while an R-value of $0.1 < R < 0.3$ would indicate a weak correlation between the studies data. Also, a p-value of less than 0.05 was used to indicate a significant correlation between the data. If a significant correlation was found, this would suggest the mussel abundance today was the same or similar to what it was at the time of Hoggarth and Grumney’s (2016) study indicating little to no change has been made to mussel abundance.

Mussel Density

Mussel density was calculated as the total number of live mussels found for all quadrats divided by the total area of the combined quadrats (5 m^2). The density of mussels per section (upper, middle, and lower) were averaged and then compared by using a single factor ANOVA. Student t-tests were then performed to determine which means, if any, were significantly different. Three different student t-tests were done including a comparison between the upper to middle, upper to lower, and middle to lower sections of the creek. A p-value of less than 0.05 was used to indicate a significant difference in the data suggesting the difference seen was not caused by chance but rather an outside factor.

Mussel density, past vs. present, was compared by using a Pearson correlation analysis where the R-value and p-value were obtained. An R-value greater than 0.5 would indicate a strong correlation between the data, an R-value of $0.3< R <0.5$ would indicate an intermediate correlation, while an R-value of $0.1< R <0.3$ would indicate a weak correlation between the studies data. Also, a p-value of less than 0.05 was used to indicate a significant correlation between the data. If a significant correlation was found, this would suggest the mussel density today was the same or similar to what it was at the time of Hoggarth and Grumney's (2016) study indicating little to no change has been made to mussel density.

Corbicula fluminea *Density*

Corbicula fluminea (Asiatic clam) density was calculated as the total number of Asiatic clams found for all quadrats divided by the total area of the quadrat (5m^2). The density of Asiatic clam per section (upper, middle, and lower) were averaged and then compared by using a single factor ANOVA. Student t-tests were then performed to determine which means, if any, were significantly different. Three different student t-tests were done including a comparison between the upper to middle, upper to lower, and middle to lower sections of the creek. A p-value of less than 0.05 was used to indicate a significant difference in the data suggesting the difference seen was not caused by chance but rather an outside factor. A Pearson correlation analysis then compared mussel density to Asiatic clam density. An R-value greater than 0.5 would indicate a strong correlation between the data, an R-value of $0.3 < R < 0.5$ would indicate an intermediate correlation, while an R-value of $0.1 < R < 0.3$ would indicate a weak correlation between the data. Also, a p-value of less than 0.05 was used to indicate a significant correlation between the data. If a significant correlation was found, this would suggest Asiatic clams may play a role in decreasing mussel density.

Asiatic clam density, past vs. present, was compared by using a Pearson correlation analysis where the R-value and p-value were obtained. An R-value greater than 0.5 would indicate a strong correlation between the data, an R-value of $0.3 < R < 0.5$ would indicate an intermediate correlation, while an R-value of $0.1 < R < 0.3$ would indicate a weak correlation between the studies data. Also, a p-value of less than 0.05 was used to indicate a significant correlation between the data. If a significant correlation was found, this would suggest the Asiatic clam density today was the same or similar to what it was at the time of Hoggarth and Grumney's (2016) study indicating little to no change has been made to Asiatic clam density.

Species Richness

Mussel species richness was calculated as the total number of live and fresh dead mussel species found per site. The number of mussel species per section (upper, middle, and lower) were averaged and then compared by using a single factor ANOVA. Student t-tests were then performed to determine which means, if any, were significantly different. Three different student t-tests were done including a comparison between the upper to middle, upper to lower, and middle to lower sections of the creek. A p-value of less than 0.05 was used to indicate a significant difference in the data suggesting the difference seen was not caused by chance but rather an outside factor.

Mussel species richness, past vs. present, was compared by using a Pearson correlation analysis where the R-value and p-value were obtained. An R-value greater than 0.5 would indicate a strong correlation between the data, an R-value of $0.3 < R < 0.5$ would indicate an intermediate correlation, while an R-value of $0.1 < R < 0.3$ would indicate a weak correlation between the studies data. Also, a p-value of less than 0.05 was used to indicate a significant correlation between the data. If a significant correlation was found, this would suggest the species richness of mussels today was the same or similar to what it was at the time of Hoggarth and Grumney’s (2016) study indicating little to no change has been made to mussel species richness.

Site Number	**Road/Park**	**Hoggarth and Grumney's Coordinates**	**Lathrop and Hoggarth's Coordinates**
Site 3	Woodside Green Park	40°02'38.7" N, 82°52'47.9" W 40.044091°N - 82.879978°W	40°02'40.9" N, 82°52'50.4" W 40.044703°N - 82.880674°W
Site 8	Big Walnut Park	39°56'57.0" N, 82°51'16.3" W 39.949177°N - 82.854546°W	39°56'41.3" N, 82°51'18.3" W 39.944804°N - 82.855074°W
Site 9	Nerfzgel Park	39°54'7.3" N, 82°52'14.0" W 39.912873°N - 82.870410°W	39°55'02.8" N, 82°52'12.7" W 39.917441°N - 82.870205°W
Site 11	East Williams Road	39°53'15.6" N, 82°54'18.4" W 39.887874°N - 82.905006°W	39°53'16.4" N, 82°54'18.0" W 39.887875°N - 82.905006°W
Site 12	Downstream Three Rivers Metropark	39°52'24.5" N, 82°54'43.6" W 39.873349°N - 82.912382°W	39°52'06.0" N, 82°55'53.0" W 39.868333°N - 82.931388°W
Site 13	Upstream London- Groveport Bridge	39°50'00.5" N, 82°59'30.2" W 39.833993°N - 82.980494°W	39°50'05.0" N, 82°59'13.0" W 39.834722°N - 82.986944°W
Site 16	Lockbourne Road	39°58'11.3" N, 82°58'11.3" W 39.819118°N - 82.970161°W	39°49'03.9" N, 82°58'11.0" W 39.817777°N - 82.969722°W
Site 18	Downstream Rowe Road Bridge	39°48'34.6" N, 82°58'38.8" W 39.809502°N - 82.977974°W	39°48'38.9" N, 82°58'31.9" W 39.810833°N - 82.975555°W
Site 20	Downstream US Rt 23 Bridge	39°47'59.5" N, 83°00'14.9" W 39.80012°N - 83.004117°W	39°48'26.0" N, 82°59'43.9" W 39.807222°N - 82.995555°W

Table 1: Site coordinates Hoggarth and Grumney (2016) versus the current study. Coordinates are provided in degrees, minutes, and seconds obtained in the field through GPS first and then provided in decimal degrees obtained through Google Earth.

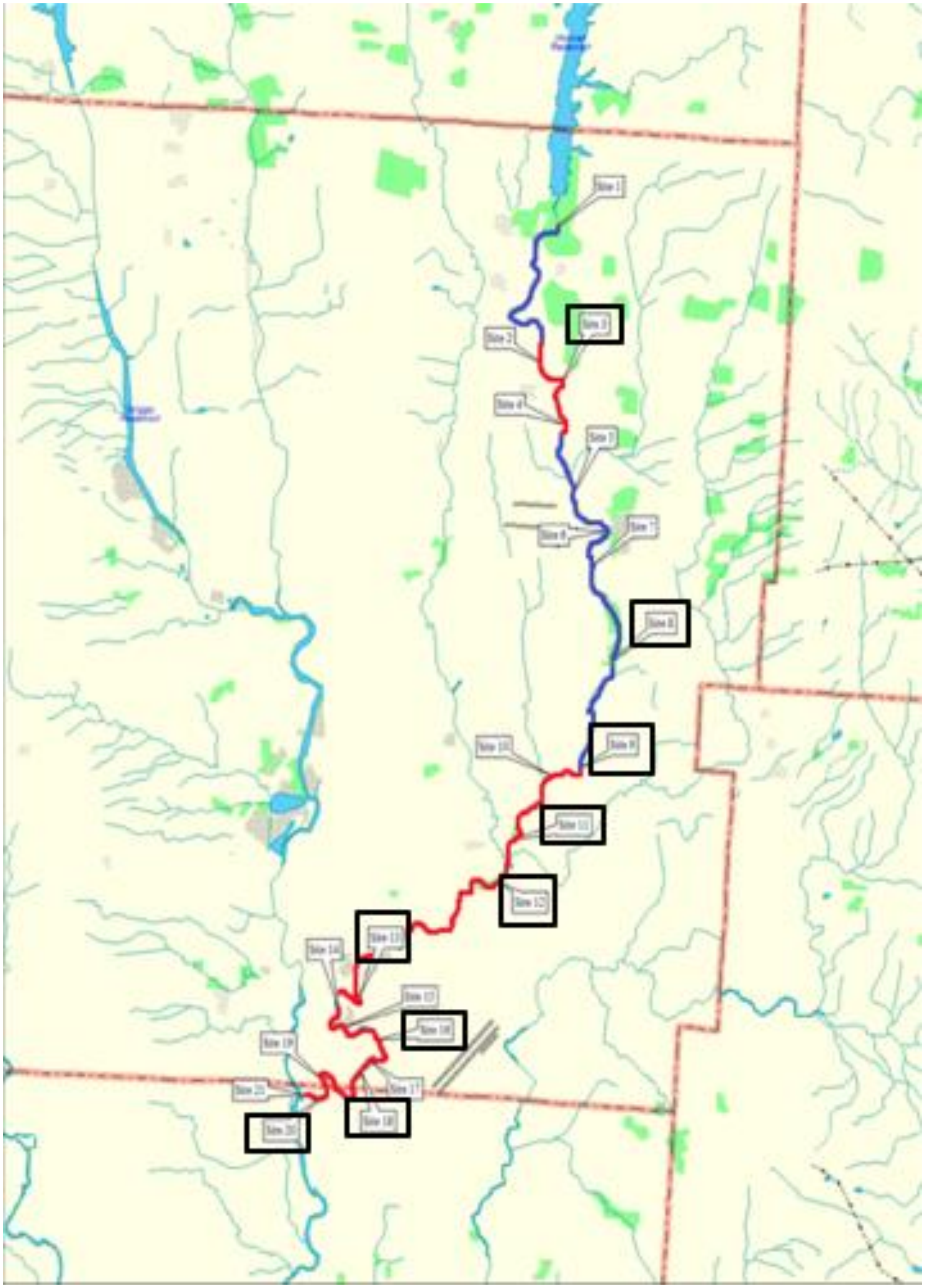


Figure 3: Lower Big Walnut Creek watershed site map from Hoggarth and Grumney (2016) with black boxes indicating the sites surveyed in the current study.

Results

Mussel Abundance

A total of 335 mussels were identified throughout lower Big Walnut Creek. Of the 335 individuals, 299 were alive, 11 fresh-dead, 24 weathered, and 1 subfossil. Two hundred twenty-nine (68.4%) extant individuals were found in the upper section of the creek with 225 (98.2%) being alive and 4 (1.8%) being fresh dead. Seven (2.1%) extant individuals were found in the midsection of the creek with 7 (100%) being alive and 0 (0%) being fresh dead. Seventy-four (22.1%) extant individuals were found in the lower section of the creek with 67 (90.5%) being alive and 7 (9.5%) being fresh dead (Table 2). The number of extant mussels collected in the three sections of the creek were statistically different ($F\ [2,6] = 10.31$, $p = 2.34 \times 10^{-5}$). Mussels were more abundant in the upper section of the creek than in the midsection ($T = 8.58$, $p = 0.00035$) and the lower section ($T = 5.19$, $p = 0.0035$). However, the midsection and lower section were not statistically different in mussel abundance ($T = 2.18$, $p = 0.081$) (Fig 4).

A total of 502 individuals were identified by Hoggarth and Grumney (2016) throughout lower Big Walnut Creek. Of the 502 individuals, 253 were alive, 133 fresh-dead, 73 weathered, and 43 subfossils. Two hundred thirty-one (46%) extant individuals were found in the upper section of the creek with 200 (86.6%) being alive and 31 (13.4%) being fresh dead. Sixty-eight (13.5%) extant individuals were found in the midsection of the creek with 23 (33.8%) being alive and 45 (66.2%) being fresh-dead. Eighty-seven (17.3%) extant individuals were found in the lower section of the creek with 30 (34.5%) being alive and 57 (65.5%) being fresh dead (Table 2). A strong positive correlation with significance was found between the two studies mussel abundance throughout lower Big Walnut Creek, $R\ (9) = 0.68$, $p = 0.043$ (Fig 5).

Mussel Density

Current mussel density values collected per site throughout lower Big Walnut Creek can be found in Table 2. An average mussel density of 3.83 mussels/m^2 was found in the upper section of the creek, an average mussel density of 0.10 mussels/m^2 was found in the midsection of the creek, and an average mussel density of 1.33 mussels/m^2 was found in the lower section of the creek. The average mussel densities collected in the three sections of the creek were statistically different (F [2,6] =8.49, p=0.018). Mussel density was higher in the upper section of the creek than in the midsection (T=2.83, p=0.037) but not higher than the lower section (T=2.08, p=0.093). There was no significant difference found between the midsection and lower section of the creek (T=1.20, p=0.28) (Fig 6). Past mussel density values collected by Hoggarth and Grumney (2016) per site throughout the creek can be found in Table 2. A strong positive correlation with significance was found between the two studies mussel densities throughout lower Big Walnut Creek, R (9) = 0.73, p= 0.024 (Fig 7).

Corbicula fluminea *Density*

Current *Corbicula fluminea* (Asiatic clam) density values collected per site throughout lower Big Walnut Creek can be found in Table 2. An average Asiatic clam density of 59.8 clams/m^2 was found in the upper section of the creek, an average Asiatic clam density of 22.27 clams/m^2 was found in the midsection of the creek, and an average Asiatic clam density of 54.87 clams/m^2 was found in the lower section of the creek. The average clam densities collected in the three sections of the creek were not statistically different (F [2,6] = 0.77, p=0.50). No section of the creek was significantly greater than the other: upper to lower (T=0.12, p=0.91), upper to middle (T=1.02, p=0.35) and middle to lower (T=1.12, p=0.31) (Fig 8). An intermediate positive correlation with no significance was found between mussel and Asiatic clam densities, R (9) =

0.43, p=0.25 (Fig 9). Past Asiatic clam density values collected by Hoggarth and Grumney (2016) per site throughout the creek can be found in Table 2. An intermediate negative correlation with no significance was found between the two studies Asiatic clam densities throughout lower Big Walnut Creek, R (9) = -0.39, p=0.30 (Fig 10).

Species Richness

A total of 19 extant species were identified throughout lower Big Walnut Creek. Species richness collected per site throughout lower Big Walnut Creek can be found in Table 2. Sixteen (84%) extant species were found in the upper section of the creek, 5 (26.3%) extant species were found in the midsection of the creek, and 10 (52.6%) extant species were found in the lower section of the creek. The number of extant mussel species collected in the three sections of the creek were statistically different (F [2,6] =6.01, p=0.037). Species were more abundant in the upper section of the creek than in the midsection (T=4.04, p=0.01) but not more than the lower section (T=1.48, p=0.20). Also, the midsection and lower section were not statistically different in species richness (T=1.38, p=0.23) (Fig 11).

A total of 24 extant species were identified by Hoggarth and Grumney (2016) throughout lower Big Walnut Creek. Species richness collected per site can be found in Table 2. Eighteen (75%) extant species were found in the upper section of the creek, 9 (37.5%) extant species were found in the midsection of the creek, and 16 (66.7%) extant species were found in the lower section of the creek. The following species were found by Hoggarth and Grumney (2016) but not in the current study: *L. complanata, M. nervosa, O. subrotundra, P. ohiensis,* and *P. grandis,* while *T. donaciformis* was the only species found in the current study but not in the previous study. A strong positive correlation with significance between the two studies mussel species richness throughout lower Big Walnut Creek, R (9) = 0.71, p=0.032 (Fig 12).

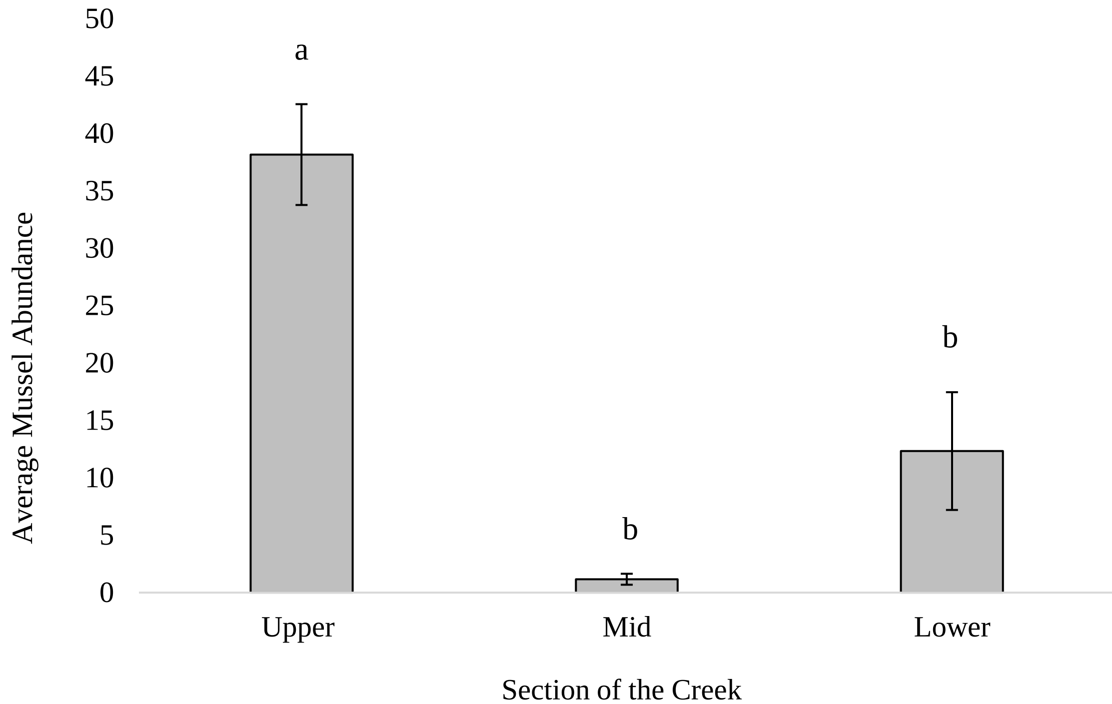


Figure 4: Average mussel abundance per section in lower Big Walnut Creek (upper=38.17, middle=1.17, and lower=12.33 mussels). The number of extant mussels collected in the three sections of the creek were statistically different ($F_{[2,6]} = 10.31$, $p = 2.35 \times 10^{-5}$). Mussels were more abundant in the upper section (a) of the creek than in the midsection (T=8.58, p=0.00035) and the lower section (T=5.19, p=0.0035) (b). However, the midsection and lower section were not statistically different in mussel abundance (T=2.18, p=0.081) (b). Standard error bars are included.

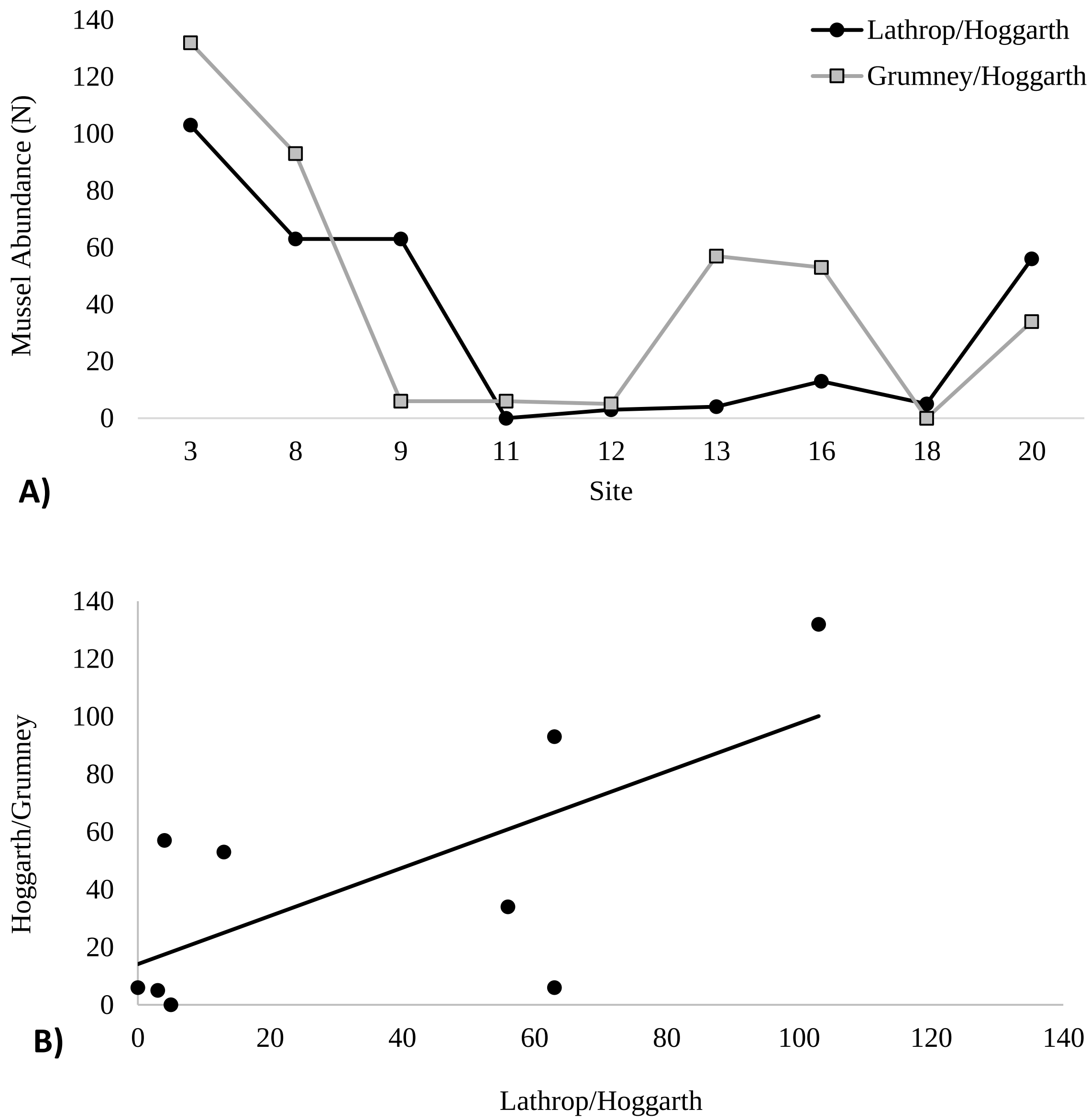


Figure 5: Mussel abundance per site in lower Big Walnut Creek. A) Mussel abundance found per site representing Hoggarth and Grumney's (2016) data in grey and the current data in black. B) Pearson correlation analysis of mussel abundance between the two studies data. A strong positive correlation with significance was found, R=0.682, p=0.043.

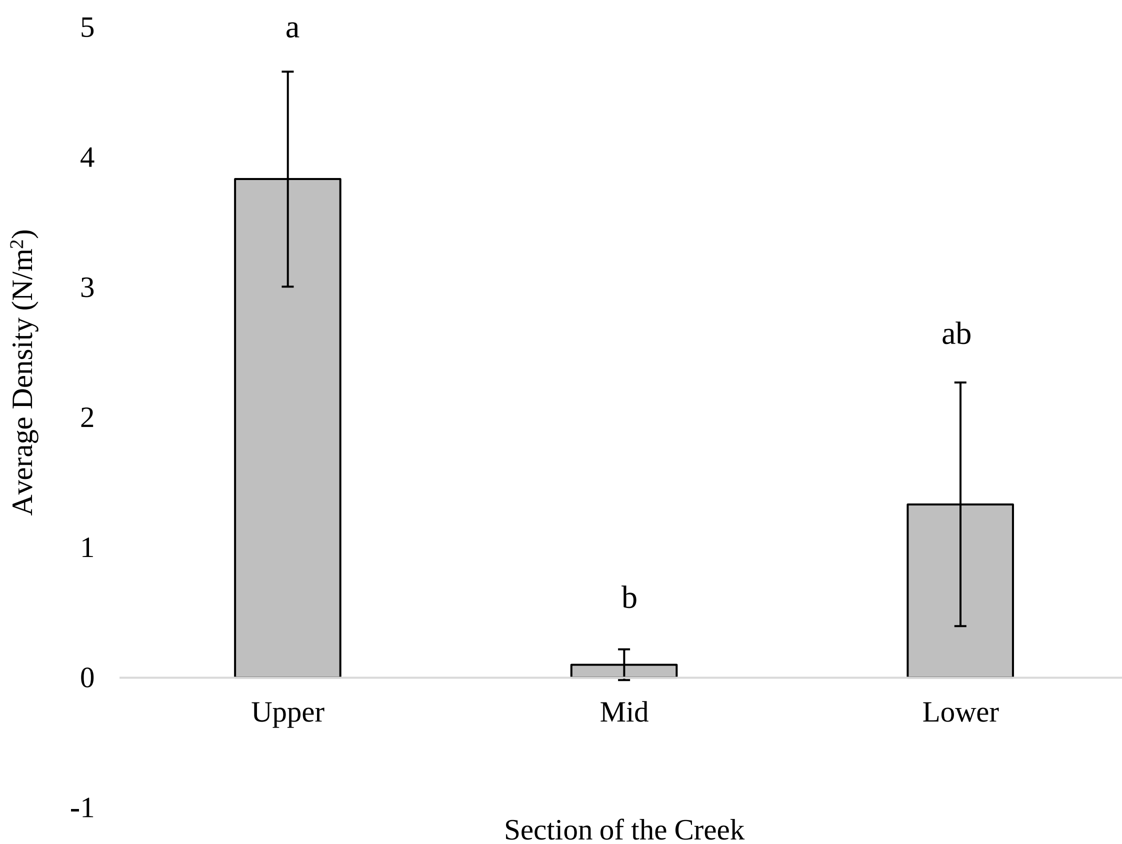
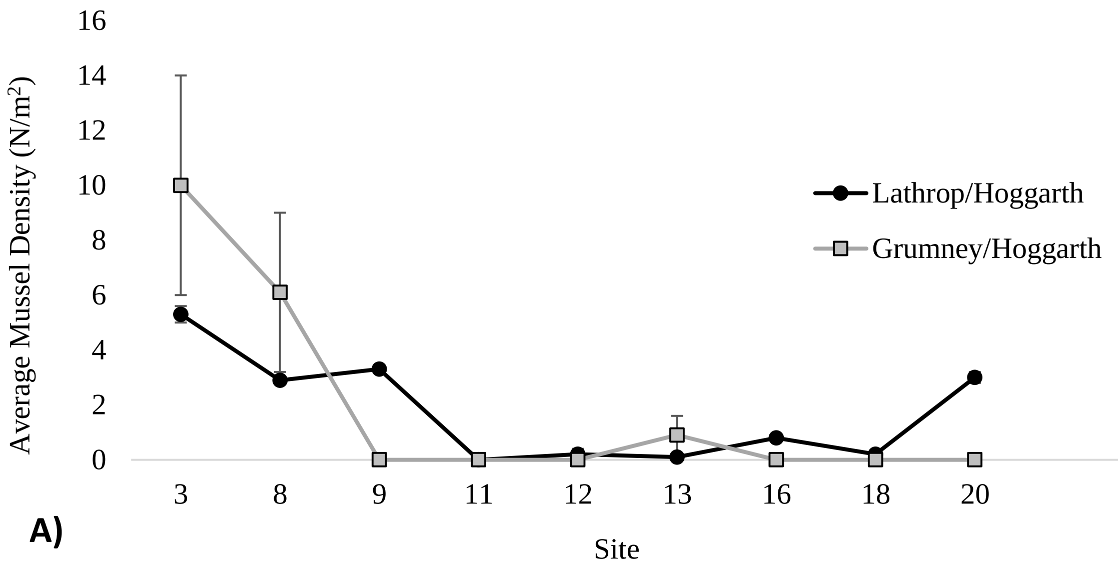
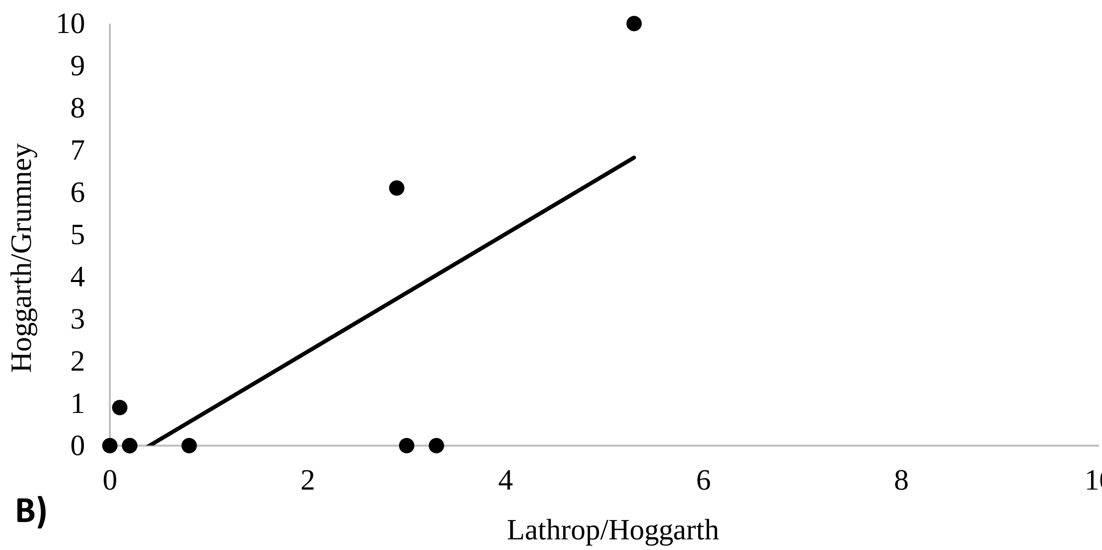


Figure 6: Average mussel density per section in lower Big Walnut Creek (upper=3.833, middle=0.1, and lower=1.33 mussels/m^2). The average mussel densities collected in the three sections of the creek were statistically different ($F_{[2,6]} = 8.49$, $p=0.018$). Mussel density was higher in the upper section (a) of the creek than in the midsection ($T=2.83$, $p=0.037$) (b) but not higher than the lower section ($T=2.08$, $p=0.093$) (ab). There was no significant difference found between the midsection (b) and lower section (ab) of the creek ($T=1.20$, $p=0.28$). Standard error bars are included.



A)



B)

Figure 7: Mussel density per site in lower Big Walnut Creek. A) Average mussel density representation of Hoggarth and Grumney's (2016) data in grey and the current data in black. Standard error bars are included. B) Pearson correlation analysis of mussel density between the two studies data. A strong positive correlation with significance was found R= 0.734, p=0.024.

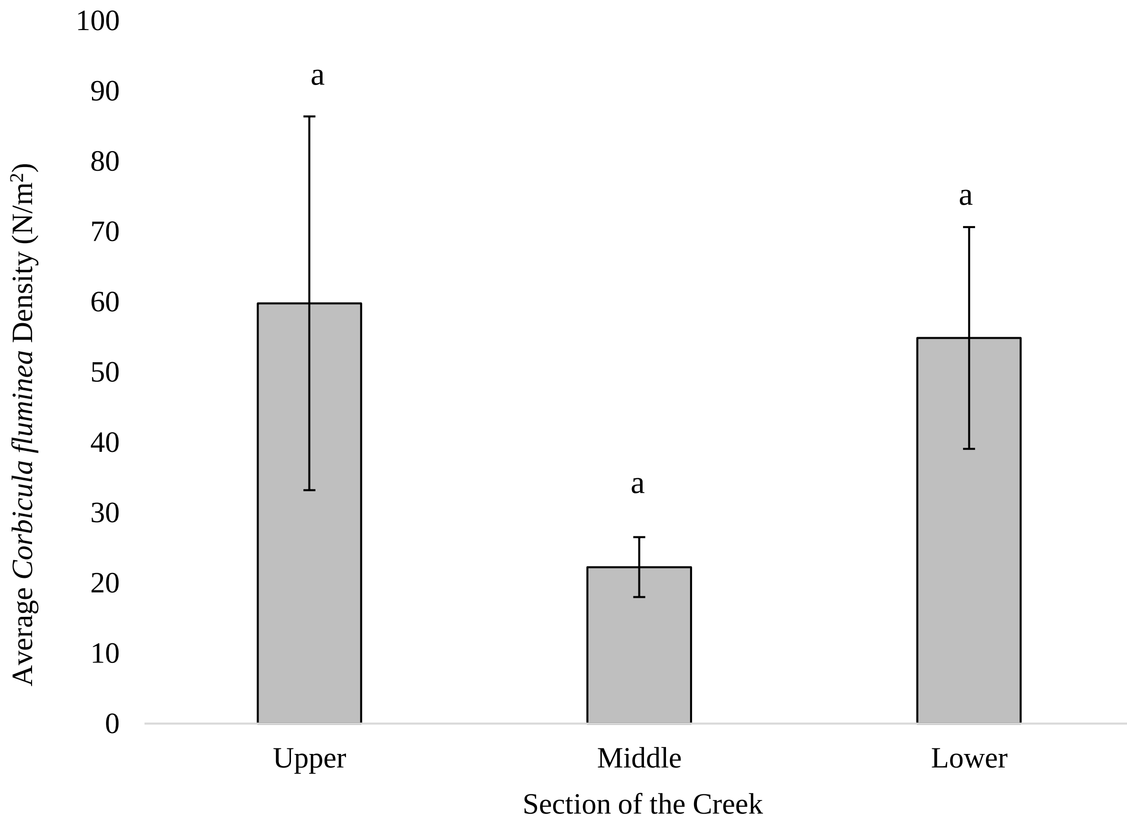


Figure 8: Average *Corbicula fluminea* density per section in lower Big Walnut Creek (upper=59.8, middle=22.27, and lower=54.87 *C. fluminea*/m^2). The average mussel densities collected in the three sections of the creek were not statistically different (F [2,6] = 0.768, p=0.50) (a). No section of the creek was significantly greater than the other as follows: upper to lower (T=0.12, p=0.91), upper to middle (T=1.02, p=0.35) and middle to lower (T=1.12, p=0.31). Standard error bars are included.

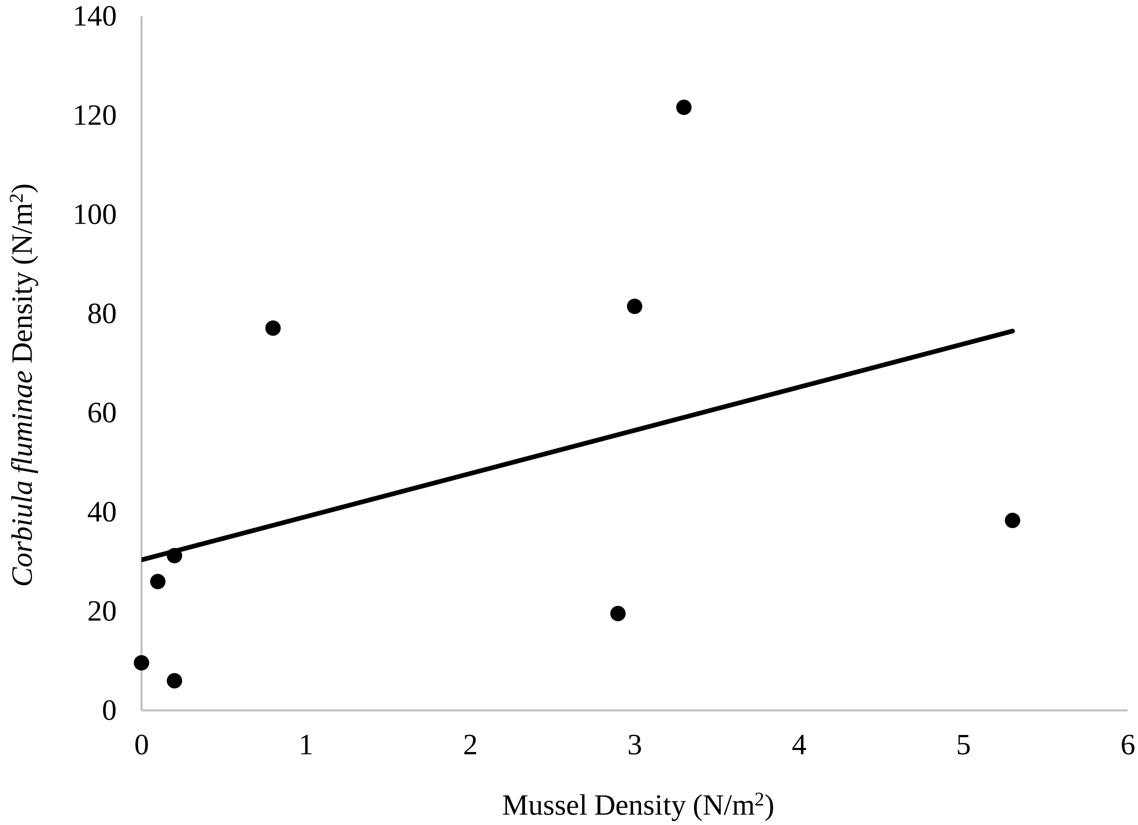


Figure 9: Mussel and *Corbicula fluminea* density per site in lower Big Walnut Creek. Pearson correlation analysis of mussel density versus *Corbicula fluminea* density. An intermediate positive correlation with no significance was found, R=0.427, p=0.25.

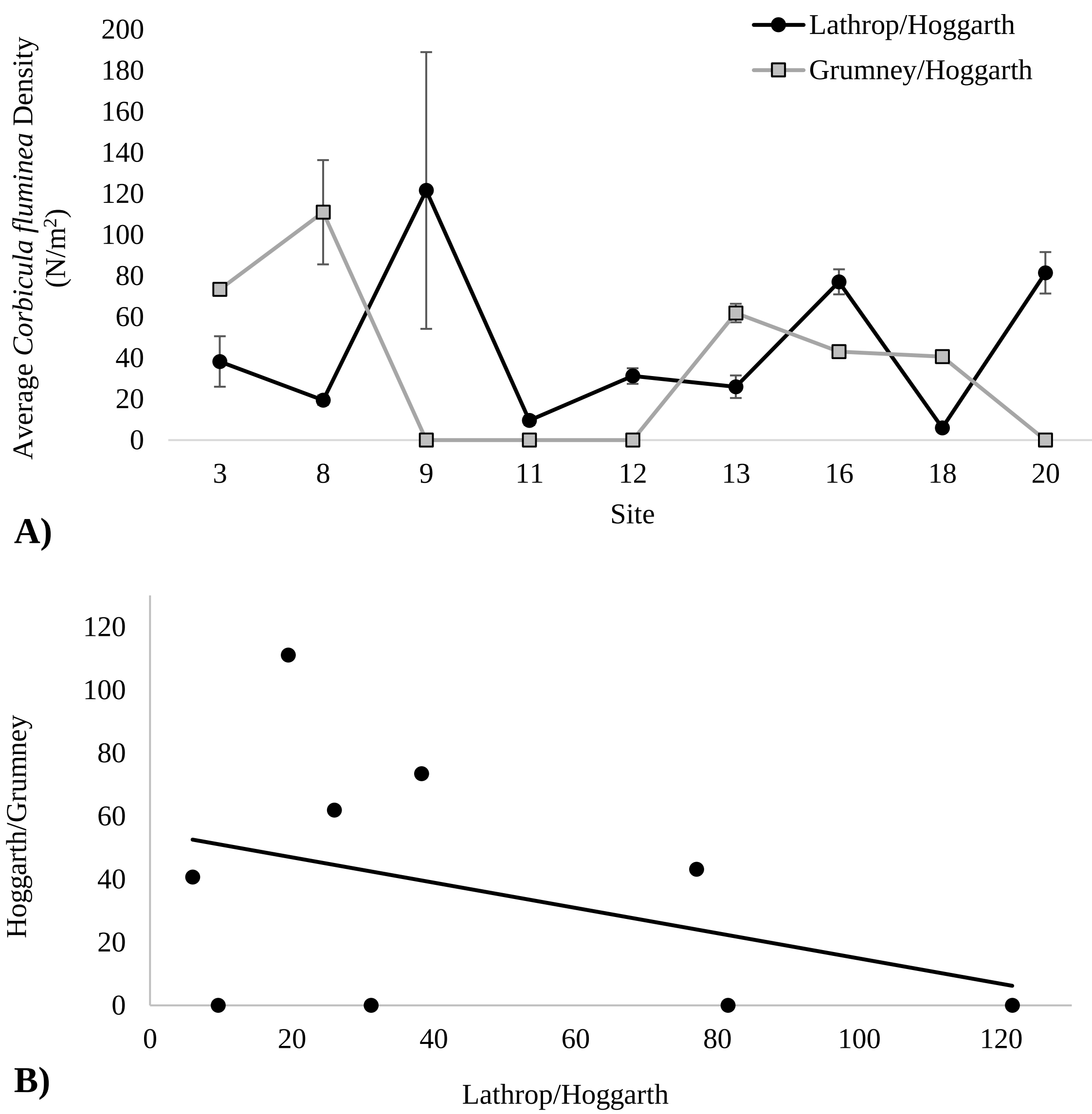


Figure 10: *Corbicula fluminea* density per site in lower Big Walnut Creek A) *Corbicula fluminea* density representation of Hoggarth and Grumney's (2016) data in grey and the current data in black. Standard error bars are included. B) Pearson correlation analysis of *C. fluminea* density between the two studies data. An intermediate negative correlation with no significance was found, R=-0.390, p=0.30.

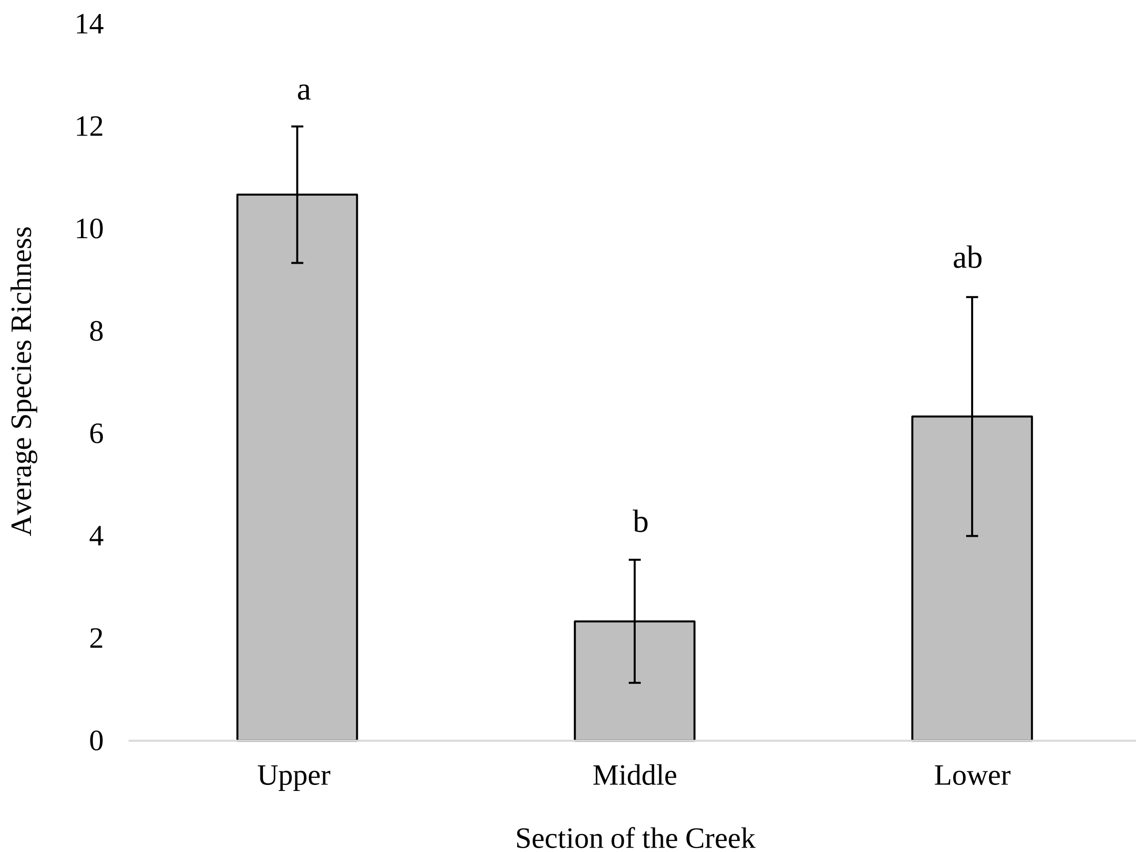


Figure 11: Average mussel species richness per section in lower Big Walnut Creek (upper=10.67, middle=2.33, and lower=6.33 species). The number of extant mussel species collected in the three sections of the creek were statistically different (F [2,6] =6.01, p=0.037). Species were more abundant in the upper section (a) of the creek than in the midsection (T=4.04, p=0.01) (b) but not more than the lower section (T=1.48, p=0.20) (ab). Also, the midsection (b) and lower section (ab) were not statistically different in species richness (T=1.38, p=0.23).

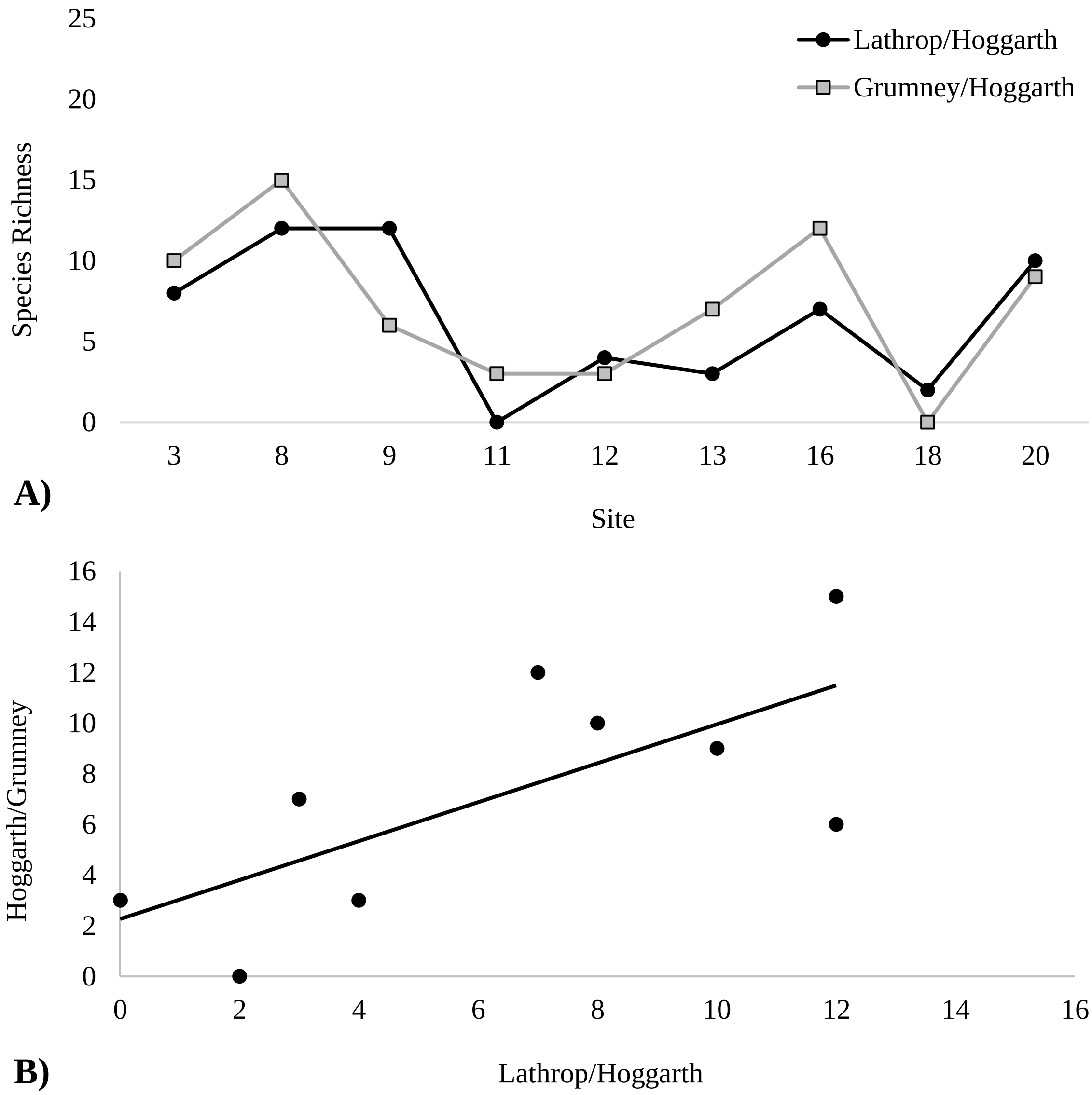


Figure 12: Mussel species richness per site in lower Big Walnut Creek. A) Mussel species richness representation of Hoggarth and Grumney's (2016) data in grey and the current data in black. B) Pearson correlation analysis of mussel's species richness between the two studies data. A strong positive correlation with significance was found, R=0.709, p=0.32.

	Hoggarth and Grumney					Current			
Site #	**Abundance (# mussels)**	**Mussel Density (mussels/m²)**	***Corbicula fluminea* Density (clam/m²)**	**Richness (#species)**		**Abundance (# mussels)**	**Mussel Density (mussels/m²)**	***Corbicula fluminea* Density (clam/m²)**	**Richness (#species)**
3	132	10	74.4	10		103	5.3	38.3	8
8	93	6.1	111	15		63	2.9	19.5	12
9	6	0	0	6		63	3.3	121.6	12
11	6	0	0	3		0	0	9.6	0
12	5	0	0	3		3	0.2	31.2	4
13	57	0.9	61.9	7		4	0.1	26	3
16	53	0	43.1	12		13	0.8	77.1	7
18	0	0	40.6	0		5	0.2	6	2
20	34	0	0	9		56	3	81.5	10

Table 2: Summary of mussel and *Corbicula fluminea* data in lower Big Walnut Creek of both Hoggarth and Grumney's (2016) data and current data.

Discussion

Mussel Abundance and Density

Hoggarth and Grumney discovered in 2013 (2016) that lower Big Walnut Creek supported a diverse mussel community but these mussels were unevenly distributed. The upper section (from Woodside Green Park to Nerfzgel Park) had high mussel abundance and density, the midsection (from East Williams Rd. to upstream London-Groveport Bridge) had low mussel abundance and density, and the lower section (from Lockbourne Rd. to downstream of US Rt. 23 Bridge) had intermediate levels of mussel abundance and density indicating recovery. This suggested some unknown disturbance had caused declines in the midsection and lower section that had not affected the upper section of the creek. They concluded the lower section had shown recovery. This study confirms their findings with some modifications and more clarity in regard to the location of this disturbance and the extent of recovery. The overall trend in the current study also followed the same three divisions within the creek in mussel abundance and density, again with the mid-section showing the lowest abundance and density. However, Hoggarth and Grumney (2016) found declines in populations to begin at Site 9, Nerfzgel Road, while the current study did not see declines until farther downstream at Site 11, East Williams Road. In fact, sites 11 and 12, downstream of Three Rivers Metropark, resulted in the lowest numbers of mussels and thus were pinpointed as the worst sites within the stretch of the creek. These declines could be attributed to some outside agent such as a stream, factory, or a historical oil spill that are affecting the sediment structure and chemistry, thus affecting the mussel community (OEPA, 2000; OEPA, 2003). Specifically, Mason Run (RM 17.9) goes to Whitehall, which has many opportunities for unregulated release of chemicals, and has one regulated outfall, suggesting this could be a source to the chemical release problem (Department of Defense, 2017). Further investigation of the sediment's structure and chemistry throughout lower BWC were performed in two additional studies. These results are unfinished and currently inconclusive.

Mussel Restoration Potential of lower BWC

According to Ohio EPA (2000, 2003), lower Big Walnut Creek supported a high diversity of organisms, especially beyond Hoover Reservoir, and had almost met Exceptional Warm Water Habitat Designation, and the diversity and water quality had stayed high since 1982. This was later supported by Watters et al. (2009) whom found 40 species of mussels, Ellenbogen and Hoggarth (2015) whom found excellent water quality, and Smoot and Hoggarth (2016) whom found 50 species of fish throughout lower Big Walnut Creek. However, Hoggarth and Grumney (2016) only found 31 species of mussels in 2012, with only 24 species being extant (77.5%). Although there was a decrease in the number of species found, there were some signs of recovery seen in the lower section of the creek in terms of increased mussel abundance and density (Hoggarth and Grumney, 2016). The current study supported this by also finding an increase in mussel abundance and density in the lower section of lower BWC, also suggesting this portion of the creek has experienced some recovery since the previous study. Specifically, the current study found: higher mussel densities in all three lower sites (16, 18, and 20), more live mussels in sites 18 and 20, and the discovery of live *Truncilla donaciformis* at sites 16 and 18. *Truncilla donaciformis* is an Ohio threatened species and thus suggests the creek is still a suitable habitat for mussel communities and potential recovery even to species that are deemed more sensitive than others. In terms of recovery potential within the midsection of lower BWC, the current study found a higher mussel density at Site 12, but numbers were still lower than hoped.

Species Richness

Hoggarth and Grumney's (2016) found that the number of mussel species per site showed the same trends as seen with mussel abundance and density: the upper section had the largest number of extant species, the midsection had the lowest number of extant species, and the lower section had an intermediate number of extant species. This study confirms their findings with the results showing the same trends. Species richness in the previous study was found to decline at Site 9 as previously shown with abundance, whereas the current study did not begin to see declines until Site 11. In fact, both Hoggarth and Grumney (2016) and the current study found that Site 11 was devoid of any living mussels. This study found more species at sites 12 and 20 as previously found with abundance and density. Only 1 extant species (*T. donaciformus*) was found within this study that was not previously found in Hoggarth and Grumney's (2016). However, Hoggarth and Grumney (2016) found 6 extant species within their study that were not found in the current study including: *L. complanata, M. nervosa, O. subrotundra, P. ohienus, P. grandis,* and *Q. quadrula.* However, the lack of these species in the current study is most likely due to the difference in methodology. In addition to the transect and quadrat sampling done within both studies, Hoggarth and Grumney also performed a general search of the creek which allotted more time for the creek to be searched for mussels, thus the opportunity to find more mussel species.

As you move down Big Walnut Creek towards its mouth, you will not only find a change in the mussel communities, you will also find a change in the size of the creek. As occurs in most rivers, they get larger as they move downstream. Although this increase is slight for BWC, along the way you encounter tributaries that are essentially ‘increasing’ the size of the creek. According to the species-area curve, as the area gets bigger so should the number of individuals and species. Watters et al. (1992) found that Unionids in the Ohio River systems follow this trend. So the uneven distribution we are seeing in lower Big Walnut Creek, where the lowest portion does not have the highest species richness, is quite shocking. We know the water quality is suitable and supportive of the mussel’s communities (OEPA, 2000; OEPA, 2003; Ellenbogen and Hoggarth, 2015) and we also know the fish communities are abundant in the creek (OEPA, 2003; Smoot and Hoggarth, 2016), so why are mussels not the richest in the lowest portion of the creek? Over the last 4 years, we have already seen an increase in species richness in the lowest two sites of the creek, sites 18 and 20, and introduction of *Truncilla donaciformis*. This suggests the lower section of the creek is working its way back to full recovery and will do so unless there is another factor we still have not considered or have not been able to suggest is negatively affecting the mussel communities.

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Appendix I: Site Specific Mussel Data

Site 3: Big Walnut Creek at Woodside Green Park (RM 30.9), at 40°02’40.9” N, 82°52’50.4” W, 40.044703°N -82.880674°W, Franklin Co., Ohio, on 10 July 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Elliptio dilatata*	spike	47	x	
2. *Elliptio dilatata*	spike	46	x	
3. *Elliptio dilatata*	spike	56	x	
4. *Elliptio dilatata*	spike	62	x	
5. *Elliptio dilatata*	spike	85	x	
6. *Elliptio dilatata*	spike	61	x	
7. *Elliptio dilatata*	spike	56	x	
8. *Elliptio dilatata*	spike	62	x	
9. *Elliptio dilatata*	spike	64	x	
10. *Elliptio dilatata*	spike	80	x	
11. *Elliptio dilatata*	spike	81	x	
12. *Elliptio dilatata*	spike	72	x	
13. *Elliptio dilatata*	spike	56	x	
14. *Elliptio dilatata*	spike	75	x	
15. *Elliptio dilatata*	spike	47	x	
16. *Elliptio dilatata*	spike	60	x	
17. *Fusconaia flava*	Wabash pigtoe	77	x	
18. *Lampsilis cardium*	plain pocketbook	101	x	
19. *Lampsilis cardium*	plain pocketbook	124	x	
20. *Lampsilis cardium*	plain pocketbook	99	x	
21. *Lampsilis fasciola*	wavy-rayed pocketbook	56	x	
22. *Lampsilis fasciola*	wavy-rayed pocketbook	75	x	
23. *Lampsilis r. luteola*	fat mucket	95	x	
24. *Lampsilis r. luteola*	fat mucket	83	x	
25. *Lampsilis r. luteola*	fat mucket	63	x	
26. *Lampsilis r. luteola*	fat mucket	64	x	
27. *Lampsilis r. luteola*	fat mucket	66	x	
28. *Lampsilis r. luteola*	fat mucket	63	x	
29. *Lampsilis r. luteola*	fat mucket	66	x	
30. *Lampsilis r. luteola*	fat mucket	72	x	
31. *Lampsilis r. luteola*	fat mucket	94	x	
32. *Lampsilis r. luteola*	fat mucket	92	x	
33. *Lampsilis r. luteola*	fat mucket	84	x	
34. *Lampsilis r. luteola*	fat mucket	61	x	
35. *Lampsilis r. luteola*	fat mucket	64	x	
36. *Lampsilis r. luteola*	fat mucket	77	x	
37. *Lampsilis r. luteola*	fat mucket	78	x	
38. *Lampsilis r. luteola*	fat mucket	87	x	
39. *Lampsilis r. luteola*	fat mucket	70	x	
40. *Lampsilis r. luteola*	fat mucket	74	x	
41. *Lampsilis r. luteola*	fat mucket	68	x	
42. *Lampsilis r. luteola*	fat mucket	84	x	
43. *Lampsilis r. luteola*	fat mucket	86	x	
44. *Ptychobranchus fasciolaris*	kidneyshell	104	x	
45. *Ptychobranchus fasciolaris*	kidneyshell	105	x	
46. *Ptychobranchus fasciolaris*	kidneyshell	125	x	
47. *Villosa iris*	rainbow	37	x	
48. *Lampsilis r. luteola*	fat mucket	58		T1Q1
49. *Lampsilis cardium*	plain pocketbook	67		T1Q1
50. *Elliptio dilatata*	spike	60		T1Q2

51. *Lampsilis r. luteola*	fat mucket	79	T1Q3
52. *Ptychobranchus fasciolaris*	kidneyshell	94	T1Q3
53. *Ptychobranchus fasciolaris*	kidneyshell	95	T1Q3
54. *Elliptio dilatata*	spike	74	T1Q3
55. *Elliptio dilatata*	spike	66	T1Q4
56. *Elliptio dilatata*	spike	58	T1Q5
57. *Lampsilis r. luteola*	fat mucket	75	T1Q6
58. *Elliptio dilatata*	spike	41	T1Q6
59. *Toxolasma parvum*	lilliput	22	T1Q7
60. *Ptychobranchus fasciolaris*	kidneyshell	66	T1Q7
61. *Fusconaia flava*	Wabash pigtoe	45	T1Q7
62. *Villosa iris*	rainbow	48	T1Q8
63. *Lampsilis fasciola*	wavy-rayed pocketbook	40	T1Q8
64. *Lampsilis fasciola*	wavy-rayed pocketbook	58	T1Q9
65. *Elliptio dilatata*	spike	52	T1Q10
66. *Elliptio dilatata*	spike	41	T1Q11
67. *Ptychobranchus fasciolaris*	kidneyshell	92	T1Q11
68. *Lampsilis r. luteola*	fat mucket	67	T1Q11
69. *Lampsilis fasciola*	wavy-rayed pocketbook	48	T1Q11
70. *Ptychobranchus fasciolaris*	kidneyshell	101	T1Q12
71. *Villosa iris*	rainbow	44	T1Q15
72. *Villosa iris*	rainbow	52	T1Q19
73. *Elliptio dilatata*	spike	50	T2Q1
74. *Lampsilis r. luteola*	fat mucket	23	T2Q1
75. *Elliptio dilatata*	spike	65	T2Q2
76. *Elliptio dilatata*	spike	59	T2Q2
77. *Elliptio dilatata*	spike	51	T2Q2
78. *Elliptio dilatata*	spike	46	T2Q2
79. *Ptychobranchus fasciolaris*	kidneyshell	101	T2Q2
80. *Ptychobranchus fasciolaris*	kidneyshell	55	T2Q2
81. *Lampsilis cardium*	plain pocketbook	109	T2Q3
82. *Elliptio dilatata*	spike	93	T2Q3
83. *Villosa iris*	rainbow	40	T2Q4
84. *Ptychobranchus fasciolaris*	kidneyshell	97	T2Q4
85. *Elliptio dilatata*	spike	73	T2Q5
86. *Elliptio dilatata*	spike	89	T2Q6
87. *Ptychobranchus fasciolaris*	kidneyshell	86	T2Q7
88. *Elliptio dilatata*	spike	59	T2Q8
89. *Elliptio dilatata*	spike	54	T2Q8
90. *Lampsilis r. luteola*	fat mucket	70	T2Q8
91. *Elliptio dilatata*	spike	72	T2Q10
92. *Elliptio dilatata*	spike	64	T2Q10
93. *Lampsilis r. luteola*	fat mucket	74	T2Q13
94. *Lampsilis cardium*	plain pocketbook	73	T2Q13
95. *Lampsilis r. luteola*	fat mucket	68	T2Q14
96. *Elliptio dilatata*	spike	59	T2Q14
97. *Elliptio dilatata*	spike	57	T2Q14
98. *Lampsilis r. luteola*	fat mucket	73	T2Q15
99. *Lampsilis r. luteola*	fat mucket	55	T2Q16
100. *Lampsilis r. luteola*	fat mucket	81	T2Q17

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. *Ptychobranchus fasciolaris*	kidneyshell	3	0	1	4
2. *Lampsilis cardium*	plain pocketbook	0	1	0	1

3. *Lampsilis r. luteola*	fat mucket	0	2	0	2
4. *Elliptio dilatata*	spike	0	1	0	1
5. *Lasmigona costata*	fluted-shell	0	1	0	1
Total		3	5	1	9

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 16/2	Q6: 19/2	Q11: 16/4	Q16: 17/0
Q2: 22/1	Q7: 14/3	Q12: 13/1	Q17: 14/0
Q3: 16/4	Q8: 6/2	Q13:17/0	Q18: 17/0
Q4: 18/1	Q9: 7/1	Q14:12/0	Q19: 4/1
Q5: 9/1	Q10: 5/1	Q15: 7/1	Q20: 4/0

Total # of C. fluminea = 253 : Density = 50.6/m^2
Total # of mussels = 25 : Density = 5.0/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 24/2	Q6: 7/1	Q11: 4/0	Q16: 2/1
Q2: 8/6	Q7: 4/1	Q12: 8/0	Q17: 2/1
Q3: 6/2	Q8: 10/3	Q13: 12/2	Q18: 1/0
Q4: 7/2	Q9: 4/0	Q14: 5/3	Q19: 0/0
Q5: 1/1	Q10: 7/2	Q15: 5/1	Q20: 3/0

Total # of C. fluminea = 130 : Density = 26.0/m^2
Total # of mussels = 28 : Density = 5.6/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Elliptio dilatata*	spike	36	0	1	0
2. *Fusconaia flava*	Wabash pigtoe	2	0	0	0
3. *Lampsilis cardium*	plain pocketbook	6	0	1	0
4. *Lampsilis fasciola*	wavy-rayed pocketbook	5	0	0	0
5. *Lampsilis r. luteola*	fatmucket	33	0	2	0
6. *Lasmigona costata*	fluted-shell	0	0	1	0
7. *Ptychobranchus fasciolaris*	kidneyshell	12	3	0	1
8. *Toxolasma parvum*	lilliput	1	0	0	0
9. *Villosa iris*	rainbow	5	0	0	0
Total number of individuals		100	3	5	1
Total individual 1) live + dead, 2) total			103		109

Site 8: Big Walnut Creek at Big Walnut Park (RM 22.3), at 39°56’41.3” N, 82°51’18.3” W, 39.944804°N -82.855074°W, Franklin Co., Ohio, on 17 July 2016.

Live mussels: Species	Common name	Length	Phase 1	Transect
1. *Amblema plicata*	threeridge	90	x	
2. *Amblema plicata*	threeridge	99	x	
3. *Elliptio dilatata*	spike	84	x	
4. *Fusconaia flava*	Wabash pigtoe	75	x	
5. *Fusconaia flava*	Wabash pigtoe	67	x	
6. *Lampsilis cardium*	plain pocketbook	129	x	
7. *Lampsilis cardium*	plain pocketbook	69	x	
8. *Lampsilis cardium*	plain pocketbook	103	x	
9. *Lampsilis cardium*	plain pocketbook	101	x	
10. *Lampsilis fasciola*	wavy-rayed pocketbook	69	x	
11. *Lampsilis r. luteola*	fat mucket	91	x	
12. *Lampsilis r. luteola*	fat mucket	73	x	
13. *Lampsilis r. luteola*	fat mucket	74	x	
14. *Lampsilis r. luteola*	fat mucket	99	x	
15. *Lampsilis r. luteola*	fat mucket	69	x	
16. *Lampsilis r. luteola*	fat mucket	74	x	
17. *Lampsilis r. luteola*	fat mucket	84	x	
18. *Lampsilis r. luteola*	fat mucket	61	x	
19. *Lampsilis r. luteola*	fat mucket	56	x	
20. *Lampsilis r. luteola*	fat mucket	73	x	
21. *Lampsilis r. luteola*	fat mucket	88	x	
22. *Lampsilis r. luteola*	fat mucket	89	x	
23. *Lampsilis r. luteola*	fat mucket	69	x	
24. *Lampsilis r. luteola*	fat mucket	92	x	
25. *Lampsilis r. luteola*	fat mucket	74	x	
26. *Lampsilis r. luteola*	fat mucket	76	x	
27. *Lasmigona costata*	fluted-shell	92	x	
28. *Lasmigona costata*	fluted-shell	99	x	
29. *Ligumia recta*	black sandshell	128	x	
30. *Potamilus alatus*	pink heelsplitter	101	x	
31. *Potamilus alatus*	pink heelsplitter	93	x	
32. *Strophitus undulatus*	creeper	75	x	
33. *Tritogonia verrucosa*	pistolgrip	136	x	
34. *Fusconaia flava*	Wabash pigtoe	67		T1Q6
35. *Lampsilis r. luteola*	fat mucket	84		T1Q7
36. *Fusconaia flava*	Wabash pigtoe	43		T1Q8
37. *Fusconaia flava*	Wabash pigtoe	63		T1Q10
38. *Lampsilis cardium*	plain pocketbook	86		T1Q10
39. *Lampsilis cardium*	plain pocketbook	104		T1Q10
40. *Fusconaia flava*	Wabash pigtoe	46		T1Q11
41. *Fusconaia flava*	Wabash pigtoe	34		T1Q12
42. *Lampsilis fasciola*	wavy-rayed pocketbook	53		T1Q12
43. *Elliptio dilatata*	spike	66		T1Q16
44. *Fusconaia flava*	Wabash pigtoe	61		T1Q16
45. *Fusconaia flava*	Wabash pigtoe	70		T1Q18
46. *Lampsilis r. luteola*	fat mucket	75		T1Q18
47. *Strophitus undulatus*	creeper	74		T1Q20
48. *Lampsilis r. luteola*	fat mucket	62		T2Q5
49. *Lampsilis cardium*	plain pocketbook	79		T2Q6
50. *Lampsilis fasciola*	wavy-rayed pocketbook	47		T2Q8
51. *Fusconaia flava*	Wabash pigtoe	45		T2Q11

52. *Lampsilis r. luteola*	fat mucket	71			T2Q11
53. *Potamilus alatus*	pink heelsplitter	98			T2Q12
54. *Ptychobranchus fasciolaris*	kidneyshell	56			T2Q14
55. *Ptychobranchus fasciolaris*	kidneyshell	54			T2Q14
56. *Lampsilis r. luteola*	fat mucket	75			T2Q15
57. *Ptychobranchus fasciolaris*	kidneyshell	49			T2Q17
58. *Fusconaia flava*	Wabash pigtoe	72			T2Q18
59. *Lampsilis r. luteola*	fat mucket	86			T2Q18
60. *Elliptio dilatata*	spike	68			T2Q19
61. *Lasmigona costata*	fluted-shell	79			T2Q20
62. *Lampsilis r. luteola*	fat mucket	93			T2Q20

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. *Amblema plicata*	threeridge	0	1	0	1
2. *Fusconaia flava*	Wabash pigtoe	0	2	0	2
3. *Lampsilis r. luteola*	fat mucket	1	1	0	2
4. *Quadrula quadrula*	mapleleaf	0	1	0	1
Total		1	5	0	6

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 5/0	Q6: 8/1	Q11: 0/1	Q16: 3/2
Q2: 1/0	Q7: 2/1	Q12: 7/2	Q17: 1/0
Q3: 1/0	Q8: 5/1	Q13: 3/0	Q18: 24/2
Q4: 6/0	Q9: 2/0	Q14: 0/0	Q19: 5/0
Q5: 2/0	Q10: 2/3	Q15: 6/0	Q20: 3/1

Total # of C. fluminea = 86 : Density = 17.2/m^2
Total # of mussels = 14 : Density = 2.8/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 5/0	Q6: 1/1	Q11: 1/2	Q16: 2/0
Q2: 8/0	Q7: 4/0	Q12: 1/1	Q17: 12/1
Q3: 2/0	Q8: 5/1	Q13: 8/0	Q18: 8/2
Q4: 2/0	Q9: 4/0	Q14: 2/2	Q19: 15/1
Q5: 4/1	Q10: 4/0	Q15: 3/1	Q20: 24/2

Total # of C. fluminea = 109 : Density = 21.8/m^2
Total # of mussels = 15 : Density = 3.0/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Amblema plicata*	threeridge	2	0	1	0
2. *Elliptio dilatata*	spike	3	0	0	0
3. *Fusconaia flava*	Wabash pigtoe	11	0	2	0
4. *Lampsilis cardium*	plain pocketbook	7	0	0	0
5. *Lampsilis fasciola*	wavy-rayed pocketbook	3	0	0	0
6. *Lampsilis r. luteola*	fat mucket	23	1	1	0
7. *Lasmigona costata*	fluted-shell	3	0	0	0
8. *Ligumia recta*	black sandshell	1	0	0	0
9. *Potamilus alatus*	pink heelsplitter	3	0	0	0
10. *Ptychobranchus fasciolaris*	kidneyshell	3	0	0	0

11. *Quadrula quadrula*	mapleleaf	0	0	1	0
12. *Strophitus undulatus*	creeper	2	0	0	0
13. *Tritogonia verrucosa*	pistolgrip	1	0	0	0
Total number of individuals		62	1	5	0
Total individual 1) live + dead, 2) total			63		68

Site 9: Big Walnut Creek at Nerfzgel Park (RM 19.3), at 39°55’02.8” N, 82°52’12.7” W, 39.917441°N -82.870205°W, Franklin Co., Ohio, on 26 July 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Alasmidonta marginata*	elktoe	70	x	
2. *Alasmidonta marginata*	elktoe	66	x	
3. *Fusconaia flava*	Wabash pigtoe	40	x	
4. *Fusconaia flava*	Wabash pigtoe	64	x	
5. *Lampsilis cardium*	plain pocketbook	91	x	
6. *Lampsilis cardium*	plain pocketbook	85	x	
7. *Lampsilis cardium*	plain pocketbook	82	x	
8. *Lampsilis r. luteola*	fat mucket	62	x	
9. *Lampsilis r. luteola*	fat mucket	77	x	
10. *Lampsilis r. luteola*	fat mucket	70	x	
11. *Lampsilis r. luteola*	fat mucket	76	x	
12. *Lampsilis r. luteola*	fat mucket	71	x	
13. *Lampsilis r. luteola*	fat mucket	89	x	
14. *Lampsilis r. luteola*	fat mucket	93	x	
15. *Lampsilis r. luteola*	fat mucket	84	x	
16. *Lampsilis r. luteola*	fat mucket	52	x	
17. *Lampsilis r. luteola*	fat mucket	60	x	
18. *Lampsilis r. luteola*	fat mucket	78	x	
19. *Lampsilis r. luteola*	fat mucket	82	x	
20. *Lampsilis r. luteola*	fat mucket	64	x	
21. *Lampsilis r. luteola*	fat mucket	64	x	
22. *Lampsilis r. luteola*	fat mucket	62	x	
23. *Lampsilis r. luteola*	fat mucket	70	x	
24. *Lampsilis r. luteola*	fat mucket	83	x	
25. *Lampsilis r. luteola*	fat mucket	95	x	
26. *Strophitus undulatus*	creeper	62	x	
27. *Strophitus undulatus*	creeper	65	x	
88. *Strophitus undulatus*	creeper	63	x	
29. *Tritogonia verrucosa*	pistolgrip	126	x	
30. *Villosa iris*	rainbow	54	x	
31. *Villosa iris*	rainbow	37		T1Q3
32. *Lampsilis r. luteola*	fat mucket	72		T1Q3
33. *Lampsilis r. luteola*	fat mucket	73		T1Q5
34. *Elliptio dilatata*	spike	52		T1Q7
35. *Elliptio dilatata*	spike	51		T1Q7
36. *Lampsilis r. luteola*	fat mucket	89		T1Q7
37. *Lampsilis r. luteola*	fat mucket	31		T1Q10
38. *Lampsilis r. luteola*	fat mucket	75		T1Q11
39. *Elliptio dilatata*	spike	88		T1Q13
40. *Ptychobranchus fasciolaris*	kidneyshell	54		T1Q14
41. *Truncilla truncata*	deertoe	37		T1Q14
42. *Lampsilis r. luteola*	fat mucket	60		T1Q14
43. *Elliptio dilatata*	spike	56		T1Q15
44. *Elliptio dilatata*	spike	78		T1Q15
45. *Elliptio dilatata*	spike	75		T1Q18
46. *Lampsilis r. luteola*	fat mucket	58		T1Q18
47. *Fusconaia flava*	Wabash pigtoe	34		T1Q18
48. *Lampsilis r. luteola*	fat mucket	57		T2Q1
49. *Lampsilis r. luteola*	fat mucket	53		T2Q2
50. *Lampsilis fasciola*	wavy-rayed pocketbook	43		T2Q3

51. *Lampsilis fasciola*	wavy-rayed pocketbook	64	T2Q3
52. *Lampsilis r. luteola*	fat mucket	46	T2Q3
53. *Lampsilis r. luteola*	fat mucket	52	T2Q3
54. *Lampsilis r. luteola*	fat mucket	64	T2Q4
55. *Lampsilis r. luteola*	fat mucket	65	T2Q5
56. *Lampsilis r. luteola*	fat mucket	60	T2Q6
57. *Lampsilis fasciola*	wavy-rayed pocketbook	26	T2Q7
58. *Ptychobranchus fasciolaris*	kidneyshell	32	T2Q8
59. *Fusconaia flava*	Wabash pigtoe	36	T2Q11
60. *Elliptio dilatata*	spike	62	T2Q12
61. *Toxolasma parvum*	lilliput	12	T2Q12
62. *Lampsilis r. luteola*	fat mucket	60	T2Q14
63. *Lampsilis r. luteola*	fat mucket	72	T2Q20

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. No mussels	--	--	--	--	--

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 62/0	Q6: 63/0	Q11: 33/1	Q16: 30/0
Q2: 73/0	Q7: 73/3	Q12: 56/0	Q17: 18/0
Q3: 57/2	Q8: 29/0	Q13: 50/1	Q18: 36/3
Q4: 39/0	Q9: 51/0	Q14: 29/3	Q19: 41/0
Q5: 69/1	Q10: 69/1	Q15: 44/2	Q20: 25/0

Total # of *C. fluminea* = 945 : Density = 189.0/m^2
Total # of mussels = 17 : Density = 3.4/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 12/1	Q6: 4/1	Q11: 14/1	Q16: 11/0
Q2: 20/1	Q7: 9/1	Q12: 23/2	Q17: 24/0
Q3: 13/4	Q8: 17/1	Q13: 10/0	Q18: 15/0
Q4: 7/1	Q9: 12/0	Q14: 14/1	Q19: 22/0
Q5: 7/1	Q10: 3/0	Q15: 13/0	Q20: 21/1

Total # of *C. fluminea* = 271 : Density = 54.2/m^2
Total # of mussels = 16 : Density = 3.2/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Alasmidonta marginata*	elktoe	2	0	0	0
2. *Elliptio dilatata*	spike	7	0	0	0
3. *Fusconaia flava*	Wabash pigtoe	4	0	0	0
4. *Lampsilis cardium*	plain pocketbook	3	0	0	0
5. *Lampsilis fasciola*	wavy-rayed pocketbook	3	0	0	0
6. *Lampsilis r. luteola*	fat mucket	34	0	0	0
7. *Ptychobranchus fasciolaris*	kidneyshell	2	0	0	0
8. *Strophitus undulatus*	creeper	3	0	0	0
9. *Toxolasma parvum*	lilliput	1	0	0	0
10. *Tritoginia verrucosa*	pistolgrip	1	0	0	0
11. *Truncilla truncata*	deertoe	1	0	0	0

12. *Villosa iris*	rainbow	2	0	0	0
Total number of individual		63	0	0	0
Total individual 1) live + dead, 2) total			63		63

Site 11: Big Walnut Creek at East Williams Road (RM 15.8), at 39°53’16.4” N, 82°54’18.0” W, 39.887875°N -82.905006°W, Franklin Co., Ohio, on 24 July 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
None collected	--	--	--	--

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
None collected	--	--	--	--	--

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 1/0	Q6: 29/0	Q11: 2/0	Q16: 2/0
Q2: 14/0	Q7: 3/0	Q12: 0/0	Q17: 0/0
Q3: 0/0	Q8: 0/0	Q13: 0/0	Q18: 0/0
Q4: 2/0	Q9: 0/0	Q14: 2/0	Q19: 2/0
Q5: 0/0	Q10: 1/0	Q15: 0/0	Q20: 1/0

Total # of *C. fluminea* = 59 : Density = 11.8/m^2
Total # of mussels = 0 : Density = 0.0/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 1/0	Q6: 13/0	Q11: 0/0	Q16: 0/0
Q2: 0/0	Q7: 9/0	Q12: 0/0	Q17: 1/0
Q3: 3/0	Q8: 0/0	Q13: 4/0	Q18: 0/0
Q4: 4/0	Q9: 0/0	Q14: 1/0	Q19: 0/0
Q5: 1/0	Q10: 0/0	Q15: 0/0	Q20: 0/0

Total # of *C. fluminea* = 37 : Density = 7.4/m^2
Total # of mussels = 0 : Density = 0.0/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. No mussels	--	--	--	--	--
Total number of individual		--	--	--	--
Total individual 1) live + dead, 2) total			--		--

Site 12: Big Walnut Creek downstream of three rivers MetroPark (RM 14.8), at 39°52'06.0" N, 82°55'53.0" W, 39.868333°N - 82.931388°W, Franklin Co., Ohio, on 6 September 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Ligumia recta*	black sandshell	138	x	
2. *Lampsilis r. luteola*	fat mucket	77		T2Q1
3. *Truncilla truncata*	deertoe	24		T2Q10

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. *Amblema plicata*	threeridge	0	2	0	2
2. *Potamilus alatus*	pink heelsplitter	0	1	0	1
Total		0	3	0	3

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 7/0	Q6: 6/0	Q11: 7/0	Q16: 23/0
Q2: 7/0	Q7: 6/0	Q12: 12/0	Q17: 10/0
Q3: 14/0	Q8: 3/0	Q13: 16/0	Q18: 7/0
Q4: 5/0	Q9: 4/0	Q14: 8/0	Q19: 11/0
Q5: 8/0	Q10: 9/0	Q15:6/0	Q20: 6/0

Total # of *C. fluminea* = 175 : Density = 35/m^2
Total # of mussels = 0 : Density = 0.0/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 5/1	Q6: 9/0	Q11: 4/0	Q16: 3/0
Q2: 15/0	Q7: 7/0	Q12: 4/0	Q17: 6/0
Q3: 15/0	Q8: 5/0	Q13: 7/0	Q18: 4/0
Q4: 15/0	Q9: 3/0	Q14: 3/0	Q19: 2/0
Q5: 11/0	Q10: 7/1	Q15: 3/0	Q20: 9/0

Total # of *C. fluminea* = 137 : Density = 27.4/m^2
Total # of mussels = 2 : Density = 0.4/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Amblema plicata*	threeridge	0	0	2	0
2. *Lampsilis r. luteola*	fat mucket	1	0	0	0
3. *Ligumia recta*	black sandshell	1	0	0	0
4. *Potamilus alatus*	pink heelsplitter	0	0	1	0
5. *Truncilla truncata*	deertoe	1	0	0	0
Total number of individual		3	0	3	0
Total individual 1) live + dead, 2) total			3		6

Site 13: Big Walnut Creek upstream of London-Groveport Bridge (RM 8.4), at 39°50’05.0” N, 82°59’13.0” W, 39.834722°N - 82.986944°W, Franklin Co., Ohio, on 30 August 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Amblema plicata*	threeridge	114	x	
2. *Lampsilis fasciola*	wavy-rayed pocketbook	75	x	
3. *Truncilla truncata*	deertoe	30	x	
4. *Truncilla truncata*	deertoe	38		T2Q6

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
No mussels	--	--	--	--	--

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 1/0	Q6: 3/0	Q11: 2/0	Q16: 3/0
Q2: 5/0	Q7: 2/0	Q12: 6/0	Q17: 14/0
Q3: 1/0	Q8: 3/0	Q13: 6/0	Q18: 10/0
Q4: 2/0	Q9: 5/0	Q14: 3/0	Q19: 5/0
Q5: 7/0	Q10: 3/0	Q15: 5/0	Q20: 14/0

Total # of *C. fluminea* = 100 : Density = 20.0/m^2
Total # of mussels = 0 : Density = 0.0/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 13/0	Q6: 7/1	Q11: 16/0	Q16: 3/0
Q2: 17/0	Q7: 12/0	Q12: 5/0	Q17: 5/0
Q3: 12/0	Q8: 4/0	Q13: 12/0	Q18: 2/0
Q4: 16/0	Q9: 6/0	Q14: 4/0	Q19: 5/0
Q5: 3/0	Q10: 10/0	Q15: 1/0	Q20: 7/0

Total # of *C. fluminea* = 160 : Density = 32.0/m^2
Total # of mussels = 1 : Density = 0.2/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil’
1. *Amblema plicata*	threeridge	1	0	0	0
2. *Lampsilis fasciola*	wavy-rayed pocketbook	1	0	0	0
3. *Truncilla truncata*	deertoe	2	0	0	0
Total number of individual		4	0	0	0
Total individual 1) live + dead, 2) total			4		4

Site 16: Big Walnut Creek off of Lockbourne Road (RM 4.5), at 39°49’03.9” N, 82°58’11.0” W, 39.817777°N -82.969722°W, Franklin Co., Ohio, on 20 September 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Amblema plicata*	threeridge	101	x	
2. *Amblema plicata*	threeridge	109	x	
3. *Lampsilis cardium*	plain pocketbook	78	x	
4. *Lampsilis cardium*	plain pocketbook	96	x	
5. *Potamilus alatus*	pink heelsplitter	98	x	
6. *Truncilla truncata*	deertoe	35		T1Q1
7. *Truncilla truncata*	deertoe	35		T1Q2
8. *Lampsilis fasciola*	wavy-rayed pocketbook	50		T1Q7
9. *Potamilus alatus*	pink heelsplitter	105		T1Q10
10. *Truncilla truncata*	deertoe	30		T2Q1
11. *Truncilla donaciformis*	fawn foot	32		T2Q2
12. *Tritogonia verrucosa*	pistolgrip	143		T2Q3
13. *Lampsilis fasciola*	wavy-rayed pocketbook	47		T2Q13

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. *Amblema plicata*	threeridge	0	1	0	1
2. *Elliptio dilatata*	spike	0	1	0	1
3. *Leptodea fragilis*	fragile papershell	0	2	0	2
4. *Potamilus alatus*	pink heelsplitter	0	3	0	3
5. *Quadrula pustulosa*	pimpleback	0	1	0	1
6. *Tritogonia verrucosa*	pistolgrip	0	1	0	1
Total		0	9	0	9

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 25/1	Q6: 25/0	Q11: 22/0	Q16: 17/0
Q2: 42/1	Q7: 16/1	Q12: 20/0	Q17: 18/0
Q3: 56/0	Q8: 18/0	Q13: 6/0	Q18: 14/0
Q4: 19/0	Q9: 28/0	Q14: 22/0	Q19: 6/0
Q5: 22/0	Q10: 16/1	Q15: 15/0	Q20: 9/0

Total # of *C. fluminea* = 416 : Density = 83.2/m^2
Total # of mussels = 4 : Density = 0.8/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 42/1	Q6: 21/0	Q11: 6/0	Q16: 3/0
Q2: 46/1	Q7: 32/0	Q12: 3/0	Q17: 2/0
Q3: 35/1	Q8: 12/0	Q13: 16/1	Q18: 3/0
Q4: 47/0	Q9: 8/0	Q14: 12/0	Q19: 1/0
Q5: 53/0	Q10: 5/0	Q15: 3/0	Q20: 5/0

Total # of *C. fluminea* = 355 : Density = 71.0/m^2
Total # of mussels = 4 : Density = 0.8/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Amblema plicata*	threeridge	2	0	1	0
2. *Elliptio dilatata*	spike	0	0	1	0

3. *Lampsilis cardium*	plain pocketbook	2	0	0	0
4. *Lampsilis fasciola*	wavy-rayed pocketbook	2	0	0	0
5. *Leptodea fragilis*	fragile papershell	0	0	2	0
6. *Potamilus alatus*	pink heelsplitter	2	0	3	0
7. *Quadrula pustulosa*	pimpleback	0	0	1	0
8. *Tritogonia verrucosa*	pistolgrip	1	0	1	0
9. *Truncilla donaciformis*	fawn foot	1	0	0	0
10. *Truncilla truncata*	deertoe	3	0	0	0
Total number of individual		13	0	9	0
Total individual 1) live + dead, 2) total			13		22

Site 18: Big Walnut Creek downstream of Rowe Road Bridge (RM 3.5), at 39°48’38.9” N, 82°58’31.9” W, 39.810833°N - 82.975555°W, Franklin Co., Ohio, on 13 September 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Potamilus alatus*	pink heelsplitter	97	x	
2. *Potamilus alatus*	pink heelsplitter	104	x	
3. *Potamilus alatus*	pink heelsplitter	117	x	
4. *Lampsilis cardium*	plain pocketbook	76		T1Q13
5. *Lampsilis cardium*	plain pocketbook	90		T2Q13

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
1. *Tritogonia verrucosa*	pistolgrip	0	2	0	2
Total		0	2	0	2

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 2/0	Q6: 2/0	Q11: 1/0	Q16: 0/0
Q2: 0/0	Q7: 1/0	Q12: 1/0	Q17: 6/0
Q3: 0/0	Q8: 1/0	Q13: 2/1	Q18: 0/0
Q4: 3/0	Q9: 1/0	Q14: 2/0	Q19: 8/0
Q5: 1/0	Q10: 2/0	Q15: 2/0	Q20: 4/0

Total # of *C. fluminea* = 39 : Density = 7.8/m^2
Total # of mussels = 1 : Density = 0.2/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 1/0	Q6: 0/0	Q11: 0/0	Q16: 1/0
Q2: 0/0	Q7: 0/0	Q12: 0/0	Q17: 2/0
Q3: 0/0	Q8: 4/0	Q13: 3/1	Q18: 1/0
Q4: 0/0	Q9: 2/0	Q14: 3/0	Q19: 1/0
Q5: 0/0	Q10: 0/0	Q15: 1/0	Q20: 2/0

Total # of *C. fluminea* = 21 : Density = 4.2/m^2
Total # of mussels = 1 : Density = 0.2/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Lampsilis cardium*	plain pocketbook	2	0	0	0
2. *Potamilus alatus*	pink heelsplitter	3	0	0	0
3. *Tritogonia verrucosa*	pistolgrip	0	0	2	0
Total number of individual		5	0	2	0
Total individual 1) live + dead, 2) total			5		7

Site 20: Big Walnut Creek further downstream of US Rt. 23 Bridge (RM 0.7), at 39°48’26.0” N, 82°59’43.9” W, 39.807222°N - 82.995555°W, Franklin Co., Ohio, on 27 September 2016.

Live mussels: Species	Common Name	Length	Phase 1	Transect
1. *Amblema plicata*	threeridge	93	x	
2. *Amblema plicata*	threeridge	105	x	
3. *Lampsilis cardium*	plain pocketbook	109	x	
4. *Lampsilis cardium*	plain pocketbook	85	x	
5. *Lampsilis cardium*	plain pocketbook	119	x	
6. *Lampsilis fasciola*	wavy-rayed pocketbook	40	x	
7. *Lampsilis fasciola*	wavy-rayed pocketbook	59	x	
8. *Potamilus alatus*	pink heelsplitter	110	x	
9. *Potamilus alatus*	pink heelsplitter	113	x	
10. *Potamilus alatus*	pink heelsplitter	69	x	
11. *Potamilus alatus*	pink heelsplitter	131	x	
12. *Potamilus alatus*	pink heelsplitter	106	x	
13. *Potamilus alatus*	pink heelsplitter	113	x	
14. *Leptodea fragilis*	fragile papershell	118	x	
15. *Quadrula pustulosa*	pimpleback	62	x	
16. *Tritogonia verrucosa*	pistolgrip	120	x	
17. *Tritogonia verrucosa*	pistolgrip	113	x	
18. *Tritogonia verrucosa*	pistolgrip	113	x	
19. *Truncilla truncata*	deertoe	28	x	
20. *Lampsilis cardium*	plain pocketbook	92		T1Q6
21. *Lampsilis cardium*	plain pocketbook	68		T1Q7
22. *Tritogonia verrucosa*	pistolgrip	130		T1Q8
23. *Leptodea fragilis*	fragile papershell	25		T1Q14
24. *Tritogonia verrucosa*	pistolgrip	127		T1Q15
25. *Tritogonia verrucosa*	pistolgrip	117		T1Q15
26. *Truncilla truncata*	deertoe	31		T1Q15
27. *Tritogonia verrucosa*	pistolgrip	122		T1Q16
28. *Tritogonia verrucosa*	pistolgrip	122		T1Q16
29. *Lampsilis cardium*	plain pocketbook	72		T1Q16
30. *Truncilla truncata*	deertoe	36		T1Q17
31. *Truncilla truncata*	deertoe	33		T1Q17
32. *Truncilla truncata*	deertoe	31		T1Q18
33. *Lampsilis fasciola*	wavy-rayed pocketbook	68		T1Q20
34. *Tritogonia verrucosa*	pistolgrip	117		T2Q1
35. *Truncilla truncata*	deertoe	30		T2Q3
36. *Lampsilis cardium*	plain pocketbook	123		T2Q4
37. *Truncilla donaciformis*	fawn foot	24		T2Q4
38. *Lampsilis fasciola*	wavy-rayed pocketbook	32		T2Q5
39. *Tritogonia verrucosa*	pistolgrip	83		T2Q8
40. *Truncilla truncata*	deertoe	35		T2Q8
41. *Potamilus alatus*	pink heelsplitter	116		T2Q11
42. *Truncilla donaciformis*	fawn foot	25		T2Q11
43. *Truncilla truncata*	deertoe	29		T2Q11
44. *Potamilus alatus*	pink heelsplitter	97		T2Q12
45. *Truncilla truncata*	deertoe	38		T2Q12
46. *Tritogonia verrucosa*	pistolgrip	112		T2Q15
47. *Tritogonia verrucosa*	pistolgrip	56		T2Q16
48. *Truncilla truncata*	deertoe	28		T2Q16
49. *Truncilla truncata*	deertoe	30		T2Q19

Dead mussels: Species	Common name	Dead	Weathered	Subfossil	Total
4. *Ligumia recta*	black sandshell	1	0	0	1
6. *Leptodea fragilis*	fragile papershell	2	0	0	2
5. *Potamilus alatus*	pink heelsplitter	1	0	0	1
8. *Tritogonia verrucosa*	pistolgrip	2	0	0	2
Total		6	0	0	6

Transect data: Transect 1 - # of *Corbicula fluminea*/mussels

Q1: 21/0	Q6: 39/1	Q11: 19/0	Q16: 27/3
Q2: 18/0	Q7: 35/1	Q12: 32/0	Q17: 35/2
Q3: 13/0	Q8: 12/1	Q13: 26/0	Q18: 27/1
Q4: 6/0	Q9: 18/0	Q14: 23/1	Q19: 18/0
Q5: 29/0	Q10: 27/0	Q15: 16/3	Q20: 17/1

Total # of *C. fluminea* = 458 : Density = 91.6/m^2
Total # of mussels = 14 : Density = 2.8/m^2

Transect data: Transect 2 - # of *Corbicula fluminea*/mussels

Q1: 12/1	Q6: 15/0	Q11: 18/3	Q16: 27/2
Q2: 9/0	Q7: 20/0	Q12: 18/2	Q17: 22/0
Q3: 11/1	Q8: 18/2	Q13: 12/0	Q18: 14/0
Q4: 17/2	Q9: 22/0	Q14: 19/0	Q19: 27/1
Q5: 18/1	Q10: 12/0	Q15: 22/1	Q20: 24/0

Total # of *C. fluminea* = 357 : Density = 71.4/m^2
Total # of mussels = 16 : Density = 3.2/m^2

Summary Site Data: Species	Common name	Live	Dead	Weathered	Subfossil
1. *Amblema plicata*	threeridge	2	0	0	0
2. *Lampsilis cardium*	plain pocketbook	7	0	0	0
3. *Lampsilis fasciola*	wavy-rayed pocketbook	4	0	0	0
4. *Leptodea fragilis*	fragile papershell	1	3	0	0
5. *Ligumia recta*	black sandshell	0	1	0	0
6. *Potamilus alatus*	pink heelsplitter	9	1	0	0
7. *Quadrula pustulosa*	pimpleback	1	0	0	0
8. *Tritogonia verrucosa*	pistolgrip	12	2	0	0
9. *Truncilla donaciformis*	fawn foot	2	0	0	0
10. *Truncilla truncata*	deertoe	11	0	0	0
Total number of individual		49	7	0	0
Total individual 1) live + dead, 2) total			56		56

Appendix II: Abstract of Ohio Academy of Science presentation

AN ANALYSIS OF SEDIMENT ASSOCIATED WITH MUSSELS (FAMILY UNIONIDAE) IN LOWER BIG WALNUT CREEK. Kierra Lathrop[1], Hayley Quinn[23], Nathan Hess[1], Joan Esson[2], Kevin Svitana[1] and Michael Hoggarth[1], Otterbein University, Department of Biology and Earth Science[1], Department of Chemistry[2], and Biochemistry and Molecular Biology[3], Westerville OH 43081.

The presence or absence of organisms provides information on three aspects of the environment: 1) the chemical and physical conditions of the environment, 2) the quality of habitats present, and 3) who else is there. Aquatic animals such as freshwater mussels provide evidence for the quality of the water where they live, the presence or absence of acceptable habitat, and, in this case due to the obligate parasitic relationship these animals have with fish and mudpuppies, the abundance and species richness of the fish community. Lower Big Walnut Creek supports mussels but the number of individuals and number of species are relatively high in the upper portion of the creek downstream of Hoover Reservoir, very low in the middle section of this portion of the creek, and intermediate near the mouth of the creek. These differences in community structure were confirmed during this study (r^2=0.5177, $p<0.05$). In addition, sediment composition changed in a linear manner from upstream to downstream (large sediments declined, r^2=0.6194, $p<0.05$, while finer sediment increased, r^2=0.5535, $p<0.05$) and so was not correlated to mussel community structure. Finally, some chemicals (such as cadmium) had much higher concentrations where mussels were lost (the middle section) suggesting that habitat is impaired and has limited the restoration of the mussel community in this reach.