Effects of *Faxonius rusticus* on erosion in a Lotic Ecosystem

By

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Abstract:

The Rusty Crayfish *(Faxonius rusticus)* is an invasive species from the Ohio River basin that has invaded Wisconsin's lotic ecosystems. This species is known to impact it environment in many ways and this study is looking at the effect that it has on erosion. Rusty Crayfish were trapped at six locations with three of them being in areas with erosion and three being in areas with stable banks along with trapping them, water samples were taken from each site to determine if this crayfish has an effect on water measurements as well. This study found that Rusty Crayfish communities are present in areas with erosion and are absent in areas with stable banks, meaning that they do have some impact on erosion. This study also found that the areas they inhabit have a low velocity of the river which normally would mean this area should be gaining sediment not losing it to erosion meaning that they are actually causing some level of erosion to happen. The areas that they are not present in have a faster velocity but experience no erosion.

Introduction:

One of the most important fresh water systems in North America are our rivers. Rivers often run through cities and have a large impact in the communities they serve. Rivers ecosystems as well as the communities along the rivers can be severely impacted by non-native or "invasive" species. Non-native species have no natural predators and often out compete the other organisms living in the aquatic ecosystem. These species often make it into the water way from recreational activities such as fishing by the fisherman either losing his bait or by accidentally spilling their bait bucket into the waterway. These non-native species can alter many aspects of the system which can cause a number of problems. Non-native species can lead to a change in predation which can result in the decrease of natural species possibly even to extinction. Also, depending on the non-native species, they can alter the ecosystem in which they live. One example of this is how the invasive Rusty Crayfish interacts with its environment to influence erosion.

In the case of the Rusty Crayfish it is suggested that they can alter the natural flow of the river by displacing native species and eliminating aquatic plants of the river which can lead to an increased rate of erosion. Rivers often experience some kind of erosion that most of the time is due to natural flow of the river and the water wanting to take the path a least resistance. While erosion is a natural occurrence for, lotic or flowing water systems, non-native species can play a big role in the rate of erosion and cause it to be more severe than it naturally would be. It is important to monitor this erosion since it can have many economic and environmental impacts. Erosion can have economic impacts because many large cities are located around waterways because of their economic value. As the waterways erode the cities are forced to protect the homes and businesses from being damaged by the river growing in width. One example of this cost to protect erosion is on the coast of California where the ocean is eroding the cliffs and causing home owners to pay to fortify the cliff to keep their homes from being lost. Companies also have this cost. The cost of protecting companies from eroding banks can cost them hundreds of thousands of dollars. Erosion also causes a lot of environmental damage as well because as the river erodes, the bank area is being decreased. While this happens naturally, when it happens at an unnatural rate species that live on the banks of waterways lose habitat too fast for them to adapt to causing them to alter how they used to live along the river. This study's objective is to record the impact that the non-native Rusty Crayfish has on area with noticeable erosion in the Menomonee River of Milwaukee. Data on the population size of the non-native species *Faxonius rusticus* (Rusty Crayfish) will be collected in the Menomonee River of Milwaukee, Wisconsin as well as data on the velocity, turbidity, and suspended sediment of the river. With this data I plan to show how the Rusty Crayfish impacts erosion as well as further understanding on how the Rusty Crayfish interacts with their environment.

Literature Review

Faxonius rusticus (Rusty Crayfish)

The Rusty Crayfish or *Faxonius rusticus* is a species of crayfish native to the Ohio River basin which covers south east Illinois, Indiana, Ohio, West Virginia, Tennessee, Kentucky, and parts of Alabama, Virginia, and North Carolina. This species is commonly used for bait by fisherman and were introduced to Wisconsin around 1960 (Minnesota Sea Grant 2016). Because it's a common bait the likely source of introduction was through this use. It is thought that they either were released by the fisherman because they did not want them after fishing or that they accidentally released them into the rivers by spilling a bait bucket into the water (Minnesota Sea Grant 2016). Since their introduction, they have spread rapidly and now can be observed in 430 lakes and streams in Wisconsin.

Crayfish can be hard to identify. In the case of the Rusty Crayfish, identification is made slightly easier by the distinct dark rusty spots on either side of their carapace (Minnesota Sea Grant 2016). These rusty spots are why they are called the Rusty Crayfish. Rusty Crayfish also reach a length of 4 inches and are normally a reddish brown color. They also have large robust claws with black tips. Rusty Crayfish also prefer to inhabit homes that are in 40 inches or less of depth.

The Rusty Crayfish has been able to spread so rapidly because of their mating behavior. The male and female mate in late summer, late fall, or early the female holds onto the sperm until spring when the water temperature has warmed (Minnesota Sea Grant 2016). The female normally lays anywhere from 80 to 575 eggs (Minnesota Sea Grant 2016). With this large amount of eggs being hatched it allows for a faster rate of infestation since more are able to reach adult hood. The female is also able to hold onto the sperm of a male until she is ready to release the eggs in the case that she does not deem it to be a safe or good time to lay them. With this ability to hold onto sperm a Rusty Crayfish female is able to start an infestation with only one female being released into a water system as long as she is holding onto viable sperm (Minnesota Sea Grant 2016).

The spread of this species is also influenced by their behavior. Rusty Crayfish are larger and more aggressive than the native species of crayfish the Virile Crayfish or *Faxonius virilis* (Olden, 2006). Along with being a very aggressive species of crayfish these arthropods can be pretty small which can make them very hard to manage and control when they are introduced to a nonnative ecosystem. There are many common ways to control the spread of these species. The most common way to manage and control this species is to capture them using crayfish traps or minnow traps. Both traps work equally well however crayfish traps are more designed to target just the crayfish. While this method is common it is not very effective because when trapping crayfish it is very hard to know how many crayfish are still in the water as well as there is no guarantee that the crayfish will go into the trap so this method becomes very tedious. (Minnesota Sea Grant 2016)

Another method is to use chemicals. These chemicals are useful but none are currently registered for crayfish control (Bills and Marking 1988) because they are not able to only target the crayfish making this method more dangerous to the environment than good. These chemicals are not able to provide a guarantee they will only target crayfish, it is also very common that other species will be killed along with the crayfish in the ecosystem. This method is extremely effective at eradicating the crayfish population but they are too harmful to the rest of the ecosystem for it to be a primary method of control. This method should only be used as a last resort.

Rusty Crayfish are a problem for Wisconsin because they can severely alter the ecosystem in which they inhabit. Rusty Crayfish have multiple impacts on the environment into which they are introduced. The main impact that is present in Wisconsin waters is the competition they have with the native species of crayfish such as the Virile Crayfish (*Faxonius virilis*). The Rusty Crayfish is larger than the native species and with this advantage in size they are better equipped to exclude the native species from their shelters and compete for limited resources (Hill and Lodge 1994; Garvey et al. 1994). Studies before and post 1985 show that the native species of the Virile Crayfish are 6 times more likely to be extirpated in the presence of the Rusty Crayfish than in rivers where the Rusty Crayfish has no presence. With the Virile Crayfish being out competed so easily by the Rusty Crayfish they have become a very common species to encounter since their introduction in the 1960's.

Another impact they have on their environment is increased fish predation on native species. The Rusty Crayfish impacts fish predation as a result of them forcing native species such as the Virile Crayfish (*Faxonius virilis)* out of their shelters. By forcing them from their shelters they are forced to be out in the open where they are easy prey for fish. As this predation rises it allows for the Rusty Crayfish to take over with even less competition (Dinatto and Lodge 1994).

Rusty Crayfish also attack the fish species. The pumpkin seed sunfish is one of these species affected by the Rusty Crayfish. The Rusty Crayfish has been observed going after the nests of these fish at night (Wilson et al. 2004). With this aggression towards fish species it has been noticed that population of Pumpkinseed sunfish have declined in population in rivers that the Rusty Crayfish have invaded (Wilson et al. 2004). Pumpkinseed sunfish are a very important fish in their ecosystem because they are an intermediate link in the food chain meaning that they are a common source of food for birds of prey and larger predatory fish.

Possibly the most destructive impact that the Rusty Crayfish have is on aquatic macrophyte beds. Aquatic macrophyte beds have a very important role in the prevention of erosion. Although their root systems are not elaborate and do not penetrate deep into the soil they help hold the soil together and deter erosion of river banks and lake shores. The Rusty Crayfish has been known to consume macrophytes which play many crucial roles in the environment of lotic ecosystems. As Rusty Crayfish populations consume more and more macrophytes the banks become increasingly less stable and erosion increases. When food is abundant Rusty Crayfish prefer to consume zoobenthos but crayfish are opportunistic feeders so when they find it difficult to find a preferred food source they will start to feed on anything they can find which can be macrophytes. All species of crayfish are known to feed on macrophytes, the Rusty Crayfish has a higher metabolic system than most species and thus need to feed more frequently (Jones and Momot 1983) meaning they are more likely to target this alternative food source. The Rusty Cray fish has also been found to target low-energy food when higher-energy food is difficult to find. (Roth, Hein and Zander 2006)

Interaction with other invasive species

The Rusty Crayfish on its own can be a tough thing to fight but it can also have positive and negative interactions with other invasive species (Maezo, Fournier and Biesner 2010) making situations in rivers and lakes with invasive species even more serious. In the 2010 study by Maezo, Fournier and Biesner they found that in areas of Canada, Rusty Crayfish populations and Eurasian Milfoil populations overlapped. Eurasian Milfoil spreads through fragmentation because they are able to grow a new plant from any cell being split from the original plant. Rusty crayfish cut the macrophytes they eat causing the plants to fragment, if the plant they are eating reproduces by fragmentation like milfoil does they can influence how fast milfoil spreads in an ecosystem. In the 2010 study they found that in areas with a high density of Rusty Crayfish that Eurasian Milfoil was decreased but in areas with medium densities of Rusty Crayfish more fragments of milfoil were found. The study came to the conclusion that the chance of this happening is low because they inhabit different areas so there should be no co-occurrence but they did find that in one area tested that had the preferred habitat for Rusty Crayfish and also had Milfoil that the Milfoil was indeed aided in its spread by the Rusty Crayfish.

Erosion

Erosion is defined as the degradation of soil. This can be natural or influenced by other forces such as humans or other organisms. Erosion is very serious because it can have many economic impacts as well as environmental impacts. As terrestrial soil erodes it can lead to desertification by destroying the plants leaving nothing behind which can lead to flooding (Fournier 2011). Although erosion is a natural occurring event it can be significantly influenced by physical factors (Fournier 2011). Water erosion is the most destructive type of erosion worldwide, causing serious land degradation and environmental deterioration (Fournier 2011). Some of these causes are man-made such as land development near the shore but others are natural such as the natural way the river flows.

Rivers have a natural flow that impacts the erosion rate. As a river curves it will meander and cause a natural cutting of the bank where erosion will be the highest. The speed of the river is also important. With increased speed the water has more force, with this force the water is able to loosen the soil and erode the bank. With this increase speed of the river nutrients, soil organic carbon and valuable soil biota are transported down the river (Fournier 2011).

Turbidity is also a factor in erosion. Turbidity is a way to measure and describe the cloudiness of water caused by suspended particles in the water. Turbidity does not actually play a role in causing erosion but it can be used for measuring the amount of erosion that is happening in a lotic ecosystem. Turbidity gives information about erosion because by looking at the cloudiness of the water you can see get a rough estimate of how much soil is in the river. It does this because as the banks erode the fine sediment will be picked up by the flow of the river. Turbidity measurements can also be compared down stretches of river to determine if other locations are experiencing erosion. As the sediment in the water is taken downstream the river will carry some of this sediment with it and if there is continues erosion it will get cloudier as it travels from one point to another.

Another important factor in erosion is the amount of suspended sediment and what that sediment is made of. Suspended sediment is important as a cause of erosion as a sign of how much erosion is happening. When sediment is carried by the water it can collide with the banks and loosen the other sediment creating more erosion. The amount of sediment is important because the more that is present in the water then more has eroded from the bank somewhere in the river. The particular sediment that is being carried by the water can also be important because it can tell us what type of river banks are being eroded. But in this study the mass of suspended sediment in the water is more important so the particular sediments in the water will not be analyzed.

Erosion is also influenced by the species that live in and around the water system. For invasive species to influence to erosion of a water system they ecosystem must be vulnerable. Some ecosystems are better at withstanding foreign invaders but others are very vulnerable. The rusty crayfish has taken advantage of the vulnerability of Wisconsin’s water ways. Wisconsin has more vulnerable waterways because the native species of crayfish was not as aggressive so they get pushed out and the fish species that each crayfish are not used to this large species that is also very defensive so they target other species and the Rusty Crayfish is allowed to spawn and invade more.

Ecosystem vulnerability:

Like most species, invasive species have to be able to change to their environment. The Rusty Crayfish has found a very inviting environment in Wisconsin and has taken full advantage of this, spreading into many of the lakes and rivers in the state. The Rusty Crayfish has been predicted to be able to establish colonies in >90% of the 292 lakes and >93% of the 546 streams studied in Wisconsin (Olden 2011). The Rusty Crayfish was able to spread to Wisconsin because the water systems of the state are very vulnerable to invasion and the Rusty Crayfish was able to quickly take over. Wisconsin also have docile native species of crayfish. Wisconsin was vulnerable to the Rusty Crayfish because since they were introduced as a bait they were not monitored. As they got released they started to extirpate the native species and grow in population. Rusty Crayfish prefer water with a pH of greater than 5.5 and a dissolved calcium of above 2.5 mg/L (Olden 2006). A majority of Wisconsin waterways meet these requirements meaning that the Rusty Crayfish is not limited to any certain region of Wisconsin.

The Rusty Crayfish has a higher probability of inhabiting draining lakes with an outlet with greater maximum depth and a higher number of boat landings and docks (Olden 2011). In streams the Rusty Crayfish is predicted to inhabit low gradient channels with high base flow, drainage watersheds with high percentages of agricultural row crops, urban land use, and carbonate bedrock (Olden 2011). The Rusty Crayfish have a higher probability of living in these areas because these areas have more nutrients so there is more food for them.

For streams the Rusty Crayfish was predicted to inhabit low gradient channels with high base flow, drainage watersheds with high percentages of agriculture row crops, urban land use and carbonate bedrock (Olden 2011). The Rusty Crayfish has been observed to move sediment in its environment to change the way the water moves in order for the species to inhabit an ecosystem more efficiently (Statzner 2000). In this study they constructed artificial rivers that had limited cover for the crayfish. The Rusty Crayfish would move the sediment around so that the flow of the water would move away from its den. With this being observed in the study they can see that the Rusty Crayfish indeed does alter its environment.

Approach:

Because the Rusty prefers to live in habitats like this, areas that meet these parameters will be used as the test sites to collect the data about the correlation between them and their effects on erosion.

Because The Rusty Crayfish can alter all these parts of their environment a study of their impact in needed. This study asks the question of are Rusty Crayfish effecting erosion in lotic ecosystems. My hypothesis for this study is that Rusty Crayfish are causing a increased amount of erosion in lotic ecosystems. All data collected will be compared to each other to see if the crayfish is indeed impacting the erosion river banks or is the erosion is caused by natural causes.

Methods:

Six sites where chosen on the Menomonee River in Milwaukee country. Three of the sites are in a segment of the river where high erosion has been recorded by the Great Lakes Tributary Modeling Program while the other three sites will be in an area where little to no erosion has been recorded also by the Great lakes Tributary Modeling Program. The sites chosen have a rage of erosion level from 1-5. Areas with lower levels have higher erosion and areas with higher levels are accreting. These sites were also chosen by using data from the USGS on established population of the Rusty Crayfish. Their data shows the Rusty Crayfish are present in these areas. The sites in high erosion will be Sites 1, 2 and 5 these sites all have a level of 1.5. The sites with stable banks with little to no erosion will be Sites 3, 4 and 6 these sites have a level of 3. Level 3 means that the bank is stable. These sites were chosen because they meet the desired habitat for Rusty Crayfish as well as they are areas where the river does no meander meaning that the river is straight. The river being straight is very important because these areas will show just how much the Rusty may be altering its habitat. Straight river stretches can naturally experience erosion but they will experience less erosion than curved areas because the water will already be traveling on a path of least resistance. If areas where chosen where the river curves they erosion present could be caused by natural causes of the river carving away the bank to create a path of least resistance.

Sites:

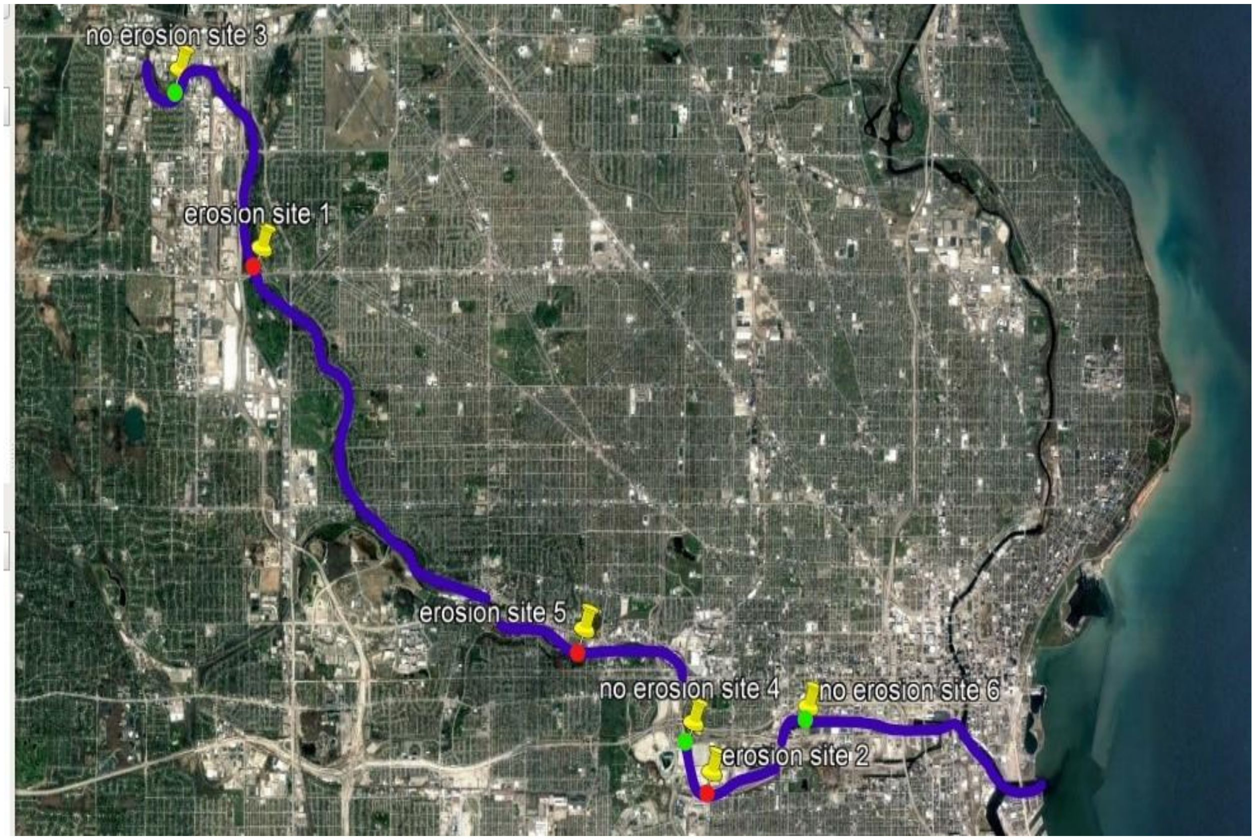

Figure 1: A map of the Menomonee River. Yellow markers are the sites used and the blue line is the general path of the river.

Twelve Crayfish traps in total were set with two traps at each of the six sampling sites. One trap was set on each side of the river in water that is deep enough so that the trap is fully submerged but not in too deep of water for crayfish to live which is normally around 40 inches or less of water. Two traps were set at each location so each side of the river can be accounted for. If only one trap was set there is a chance that only the population on one side of the river is represented. Originally the traps were set for a period of 24 hours but no crayfish were caught in those samples so another attempt was needed. The second time the traps were baited with equal portions of salmon and left for a period of four days. Four days was chosen because any crayfish caught would be able to survive that time in the trap with the food provided and so that a more representative sample could be collected from the river. Salmon was chosen as the desired bait because on fishing websites they said that it is a very oily and aromatic fish. Fish with a high amount of oil are preferred because their scent will carry down the river better and attract the most amount of crayfish. After the traps were collected the crayfish were evaluated to make sure no other species are being collected. No other species of crayfish were collected in any of the traps. The crayfish will not be released since they are an invasive species. They were taken back to the Carthage College campus and disposed of.

Water tests were conducted at each location. These tests are the **velocity** of the water, the **turbidity** of the water, and the **suspended sediment** of the water. These test where chosen because they are all important factors of erosion and will help determine of the Rusty Crayfish is indeed changing the environment and influence erosion or if they have no effect of the environment and the erosion is just caused by normal causes.

Velocity:

The velocity of the water was collected because with an increased velocity the more erosion could be present on the banks of the river.

Data on the velocity of the river was collected by having one person hold out a 1 meter long piece of rope. Another person was on the bank with a stopwatch. After the rope has been placed an orange was floated down the river while the person on the bank of the river recorded the time it takes for the orange to travel 1 meter. This test was conducted once at each of the six locations. Mean values were calculated so that both erosion and stable bank locations can be compared.

Turbidity:

The turbidity of the water is the haziness of the water. Turbidity is an important measurement because the haziness of the water gives information on much suspend particles are in the water. These suspended particles can cause erosion by knocking loose the fine sediment.

The turbidity of the water was collected by using a turbidity tube. A turbidity tube is a clear tube that is marked on one side with measurements and a secchi disk at the bottom. At each location a turbidity tube was filled with water. Looking from the top of the tube the depth at which the secchi disk is last visible was recorded.

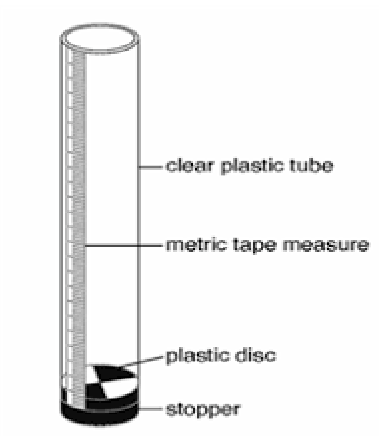

Figure 2. A turbidity tube.

This depth gave information about the visibility of the water. The lower the depth is the more sediment and other inorganic and organic matter are in the water and the greater the depth the less matter is suspended in the water.

Suspended Sediment:

Data of suspended sediment will be collected because suspended sediments have an effect on erosion as well as give information on what sediment is being eroded and how much of it being eroded.

Suspended sediment data was collected by collecting 1 sample from each site. 1 sample of suspended sediment for this lab is defined as a full 16 oz. mason jar. A mason jar was chosen because it is a large enough container that will be able to collect a large amount so that the sample can be analyzed multiple times in case an outlier is present. To collect the sample the mason jar was placed into the river about half way to the bottom with the open end facing the current. This procedure was chosen so that the sample would not be from the top of the river water column where almost none of the suspended sediment would be as well as not from the bottom of the river so that it would not have a increased amount being so close to the sediment resting on the bottom. The open end of the jar is facing the current so that it will collect the suspend sediment, if it was facing the other way the closed end would block all the sediment from entering the jar.

The jars were taken back to Carthage College and analyzed in an environmental science laboratory. Whence in the laboratory the mason jars were shaken to get the settled sediment back into suspension in the water. Then a 500 ml sample was taken from the Mason jar sample. Using an electronic weighing device the 500 ml was weighed. The 500 ml sample was then filtered through filter paper to separate all the suspended sediment from the water. The water sample was set aside to obtain a final measurement of the amount of water in the sample. After that water and sediment was fully separated by the filter paper it was dried in a drying oven. The dried suspended sediment was then weighed. The weight of the sediment was then divided by the weight of the water to determine the percentage of sediment that was in the water.

Data analysis:

The data collected from field will be placed into a single excel file. The data is used to construct multiple graphs that will show the relationship between the Rusty Crayfish and the velocity, turbidity, and suspended sediment. These graphs will allow for an idea of whether or not the Rusty Crayfish is having a real effect on erosion or if it is just a natural occurrence. Because of the limited number of site being sampled an in depth statistical analysis is not possible but with the data collected it is possible to construct the graphs seen in the results.

Results:

The results from this study show in areas with erosion there are Rusty crayfish populations and in areas with no erosion they are absent (figure 3).

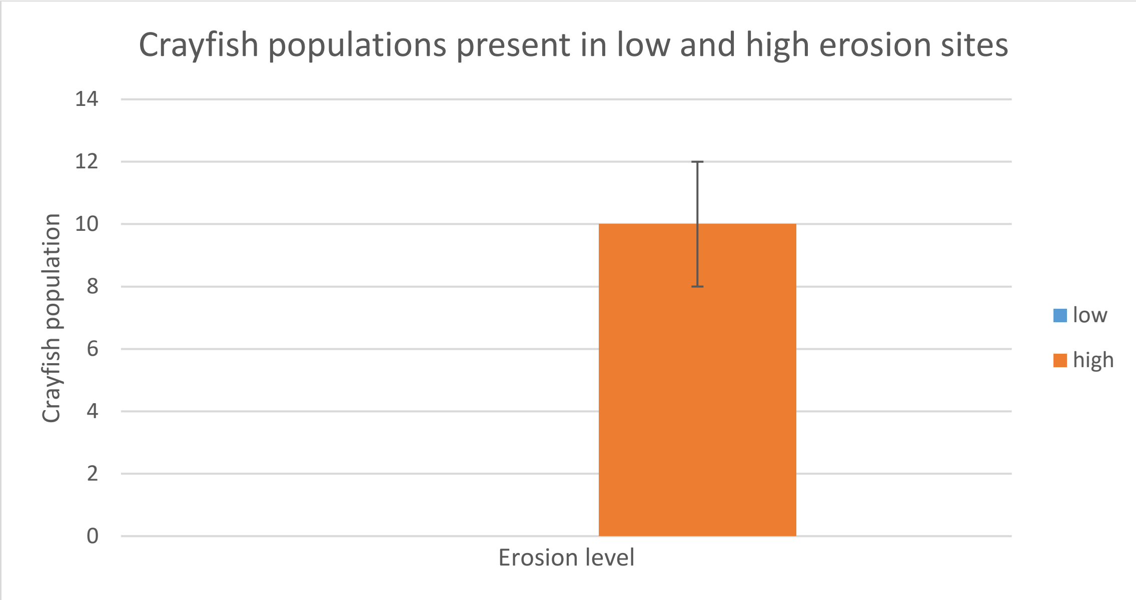

Figure 3: This graph shows average population of crayfish at low and high erosion sites

The figure 3 erosion values are based on a scale of 1-5 with one being lots of erosion and 5 being accreting. The results from this study show that in 3 of the sites the erosion is rated at a 1.5 level while the other three are at level 3. These low and high areas were then combined into a general low and high value and their average crayfish populations were graphed with them to show how they compare. When a T-test was run on this data it produced a P value of 0.013. Since the P value is below .05 it means that the difference between crayfish populations at the sites is more significant meaning that crayfish do live in areas with high erosion over areas with low erosion.

Rusty Crayfish have no effect on the water quality as can be seen in 4 and 5. In figure 4 and 5 no real difference is seen between the sites but in figure 4 velocity of the river is higher in areas without crayfish and low in areas with crayfish.

This study also found that the water quality measurements largely were not affected by the erosion present. The only value that showed a difference was erosion as seen in figure 4. The velocity of the river was faster in areas with stable banks and low in areas or erosion. Normally this would be the opposite since it takes faster moving water to erode banks unless the rusty crayfish indeed is causing some erosion.

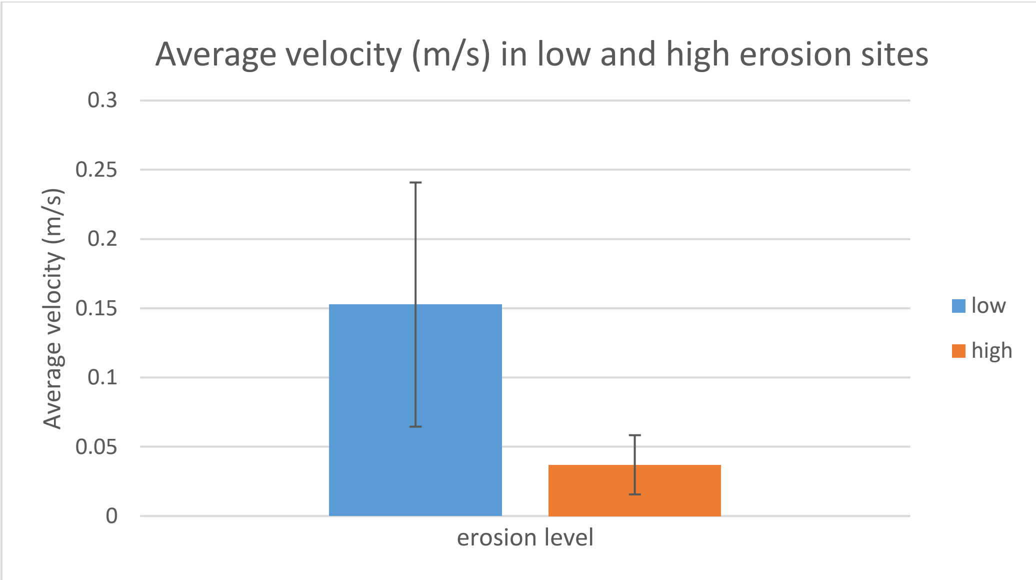

Figure 4: This graph shows the relationship between the velocity of the Menomonee River and how it relates to areas with different erosion levels.

Figure 4 shows that areas with a high erosion had slower moving water. It also shows that areas with a low erosion had faster moving water. Slow moving water does not erode banks like fast moving water does. Seeing that the areas with erosion have slower water supports the hypothesis that a natural cause like velocity is not causing the erosion but something else is. When a t-test was run on this data it yielded a P value of 0.0012. This value is lower that 0.05 meaning that the difference between these values is significant.

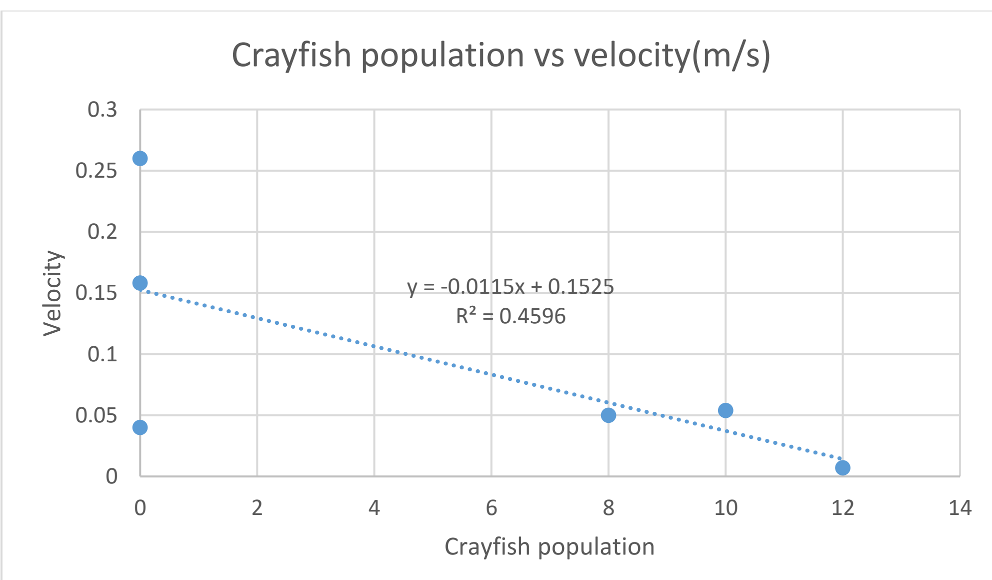

Figure 5: This graph shows the relationship between the velocities of the Menomonee River in relation to the population size of the Rusty Crayfish.

In results from figure 5 show the rusty crayfish does not impact the erosion is locations they populate. Velocity of the river is a common factor in erosion and areas with more erosion typically have faster moving water. But in the case of this study the water is actually moving fastest in areas with no crayfish which also happen to be areas with stable banks.. When this data was tested with a regression a P value of 0.139 was achieved. This value is higher than 0.05 meaning that the relationship between these values is not significant. Since it is not significant it means that crayfish impact on velocity is not significant.

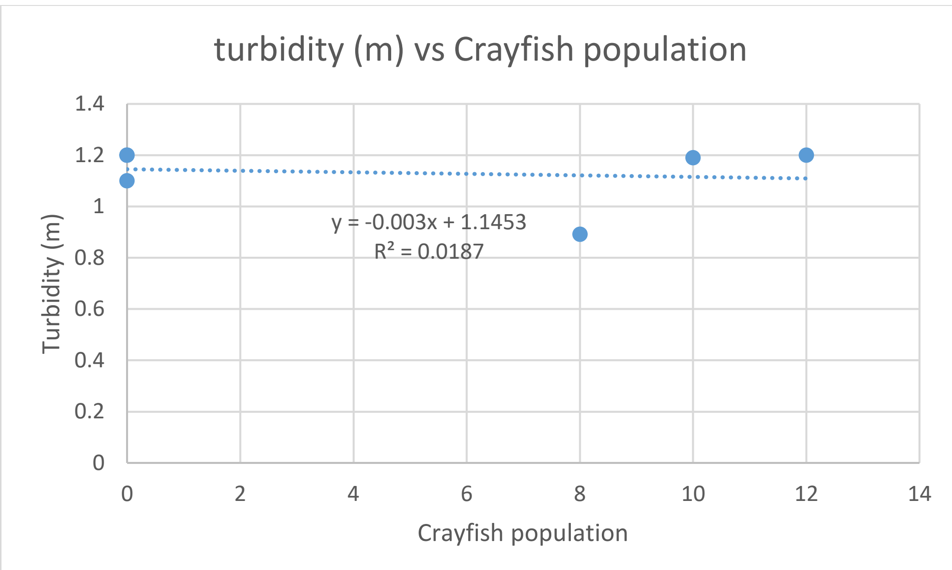

Figure 6: This graph shows the relationship between the Turbidity of the Menomonee River in relation to the population size of the Rusty Crayfish. Rusty crayfish populations.

Figure 6 shows that crayfish populations do no impact turbidity in the river. Because they don't have an impact on turbidity this means that the Rusty Crayfish might not have a large impact on how much sediment is making the water cloudy and thus might not be the cause of the erosion being studied. When tested with a regression analysis a P value of 0.795 was achieved. This value is significantly above 0.05 meaning that the relationship between crayfish and turbidity is not significant.

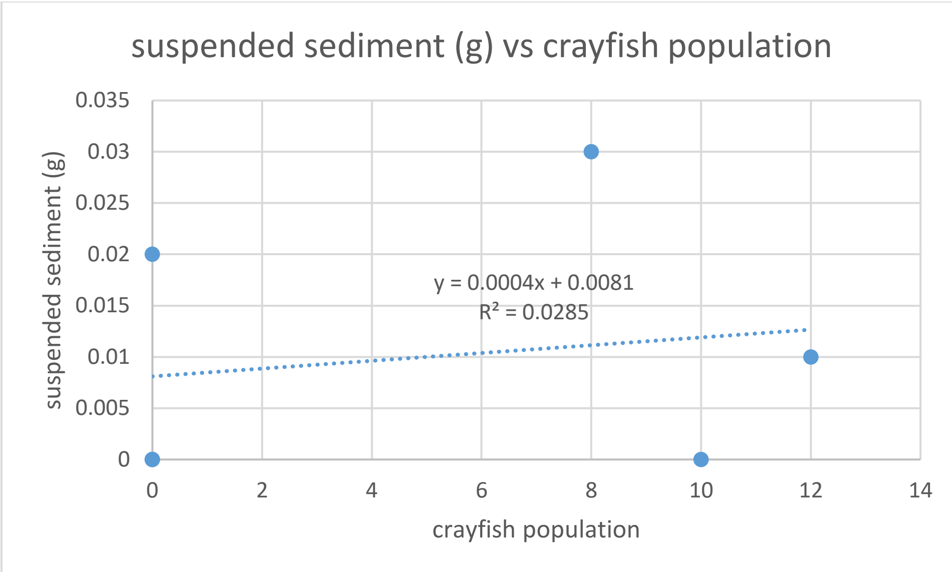

Figure 7: This graph shows the relationship between the suspended sediment of the Menomonee River in relation to the population size of the Rusty Crayfish.

Figure 7 does not show much of significance. Sites with crayfish populations do not have very high values and they are not much different than locations without crayfish meaning that the crayfish are not causing more sediment to be free in solution. Because the crayfish do not appear to be causing more sediment to be free is solution this does not support the hypothesis that crayfish are effecting the erosion levels because if they were more sediment should be seen in the water as they dislodge it from the bank. When this data was tested with a regression analysis a P value of 0.749 meaning that the relationship between crayfish and suspended sediment is not significant.

Discussion:

There was a specific trend and relationship that was expected to be seen in this study. Ideally the relationship between the Rusty Crayfish and erosion in the Menomonee River was supposed to be clear and concise showing that the Rusty Crayfish is effecting erosion with the data fully supporting this. But while the data does show a relationship it appears that the Rusty Crayfish is not the definitive cause of the erosion.

Data supporting the hypothesis of this study can be seen in figure 3 where population and erosion are graphed together. The sites with erosion had an average population of 10 while sites with low erosion had an average population of 0. This evidence supports that crayfish do live in areas with higher erosion so they might have an effect on erosion. But these populations are not as large as expected as well as the initial setting of traps led to no capture of any crayfish so a second attempt was needed to capture them. Population size also does not give enough information to tell if erosion is impacted by Rusty Crayfish. The velocity of the river was also measured in this lab and the measurements created a surprising finding. In areas with stable banks the velocity was much higher than areas with more erosion. In most cases of erosion the velocity of the river is faster in those areas but instead in the sites sampled areas with low velocity had higher erosion. This is interesting because normally low velocity areas are depositing soil not taking it away. The regression test on the data also showed how this relationship is not significant because the P value was larger than 0.05 at 0.139. Since the P value was so high and this supports my null hypothesis that Rusty Crayfish are not effecting erosion.

The data from the tests done on the water show that across all sites the values were very similar which does not support the hypothesis that the Rusty Crayfish is influencing its environment and causing more erosion. Ideally the data would have shown an increase in turbidity and suspended sediment in areas with larger crayfish populations. The areas with erosion should have shown higher values for these factors because both of them are good indicators at how a river bank is dealing with erosion. The higher these values are the greater the erosion should be. The velocity of the river was also measured in this lab and the measurements created a surprising data set. In areas with stable banks the velocity was much higher than areas with more erosion. This could be attributed to the fact that the banks of areas with no erosion are comprised of larger rocks while the areas with erosion are comprised of more clay and soil.

Overall the data supports that the Rusty Crayfish do not have an effect on erosion in lotic systems and that the erosion must come from another source because all the statistical test show that the Crayfish population in relation to the water values were not significant. The data on turbidity and suspended sediment did not support the hypothesis that the Rusty Crayfish was actively eroding the banks but the Rusty Crayfish was only seen in areas with erosion as well as the velocity of the river was decreased in areas with erosion which would normally only be seen in areas with depositing no eroding. With the velocity being lower in areas with crayfish allow for a reason to believe that Rusty Crayfish might have a effect on erosion but they are obviously not the only cause.

Overall this study show that Crayfish might be impacting erosion slightly since they do inhabit areas with high erosion but based on the data recorded and the statistical test done of it there is no correlation between the Rusty Crayfish and erosion in the Menomonee River. The erosion that is present in the river is most likely due to natural factors.

Areas of this study that could be improved are the length of the study. This study only lasted four days when it could have been done over a longer time, doing it over a longer time period would allow for accurate measurements of erosion to be taken and multiple captures of crayfish to determine if the crayfish caught truly represent the population. With this longer study and more data would allow for significant statistical testing to determine of the Crayfish population is significant to the erosion or if it wasn't. More studies over longer periods of time will have to be done to determine how much erosion the Rusty Crayfish actually account for.

Future studies:

This study answers the question that rusty crayfish do not have an effect on erosion. This study would improve if the erosion data as well as turbidity, velocity, and suspended sediment was recorded over a year or more so that an accurate measurement could be taken of how the Crayfish are actually effecting their environment or if they aren't.

Some of the sites sampled had more rocks which are harder to erode. This could be the reason why the velocity was higher in some areas but most sites were similar. In another study this could be accounted for by creating an artificial river so that all aspects are the same or a greater area could be researched meaning more sites that more similar can be compared. This wasn't able to be done in this study because of restraints on timing and money to travel to expand the area researched.

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