Monitoring a Small Northwestern Iowa Stream Undergoing Watershed Changes

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Abstract -Stream ecosystems are influenced by their watersheds. Intact watersheds support high water quality and habitat heterogeneity, while providing native allochthonous input. In Iowa, watershed degradation associated with agricultural activities and expanding residential development negatively impacts streams by increasing sedimentation, pesticide exposure, and eutrophication. Our study continued a monitoring program of a low order stream in Sioux County, Iowa. As the surrounding watershed shifts from agricultural to residential use, we are recording changes in stream biodiversity and water quality. At three study sites, we documented the stream's physical and chemical characteristics and collected macroinvertebrate samples. We also introduced various substrata (gravel, maple leaves, and pavers) to the stream to observe macroinvertebrate colonization. As expected, we found the stream dominated by taxa tolerant of poor water quality. Our results indicate that substrate type significantly affected colonization, with gravel supporting the lowest richness and abundance of macroinvertebrates. Overall, location and colonization month (September vs. October) only affected a subset of our samples. These results differ markedly from those of a similar 2018 study. We anticipate that the results of this study will be compared to future work, enabling researchers to monitor how the stream responds to changes in the watershed and hydrological events.

INTRODUCTION

Waterways are intimately connected to their surrounding landscapes. As human activities change those landscapes, for better or worse, the impacts can be seen in lotic habitats. Many streams in Northwest Iowa experience degradation by agricultural activities, which result in increased sedimentation, lower habitat heterogeneity, pesticide exposure, and eutrophication (Herringshaw et al. 2011). Although less common in Iowa, residential growth also negatively impacts terrestrial and lotic habitats. Only macroinvertebrate taxa tolerant of these conditions persist in impacted streams, resulting in relatively low taxonomic richness (Hilsenhoff 1988).

Our study area is undergoing watershed transition from agricultural use to increasing residential development. Long term, we are interested in exploring how this transition affects the stream draining the watershed. We are also exploring the effects of increasing habitat heterogeneity in this degraded low-order stream by introducing multiple colonization substrata (gravel, concrete pavers and leaf bags). We hypothesized that abundance and richness of colonizing macroinvertebrates would be significantly higher in and on more complex substrata (gravel and leaf bags vs. pavers), especially if the substrate offered additional allochthonous resources (leaf bags). We hypothesized that colonization would differ in September vs. October due to seasonal changes in water temperature and flow. We also hypothesized that the richness would be higher immediately downstream from a small conservation easement bordering the stream between two of our study locations. Repeating this colonization experiment in future years should enable us to assess changes to the steam during the ongoing watershed transition.

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STUDY SITE AND METHODS

Location:
We set up colonization substrata at three locations in a 2nd order tributary of the Floyd River near Orange City, Iowa. This small stream flows from east to west through a 9km^2 watershed dominated agricultural development (~6.3km^2, Figure 1). Note: We excluded 2km^2 from the total 11km^2 watershed because that surface water is diverted to a different watershed via Orange City storm drains. Our three colonization sites, West, Middle, and East were separated by 482m and 337m respectively (Figure 1). The 482m span separating the West and Middle site runs through a small conservation easement. The stream channel is steep-sided with the bed dominated by unconsolidated silty substrate. Hard substrata (broken concrete and cement culvert pipe) are present at walking bridge and bridle trail crossings (Figure 2). Naturally occurring debris packs regularly build up at the walking bridge supports.

Biological, physical, and chemical characterization:
We took qualitative macroinvertebrate samples from the stream sides and bottoms of each study site with 250µ mesh dip nets. The samples were preserved in 70% ETOH and processed in the lab. We estimated discharge using a flow meter (Flo Mate 2000) and cross-sectional stream area. CHEmets visual test kits were used to measure dissolved oxygen and phosphate. We used Hach test strips to assess pH and levels of nitrite, nitrate, and chloride. Physical and chemical characteristics were assessed throughout the study period.

Manipulations:
Our introduced colonization substrata included smooth concrete pavers, 1cm mesh bags filled with 300g of smooth gravel and 1cm mesh bags filled with 5g of dried *Acer saccharinum* leaves. On August 27, 2020, 8 sets gravel bags and leaf bags were tied to walking bridge supports and submerged at both the West and Middle sites. We also placed 2 concrete pavers at each of the three sites just upstream of concrete culverts. Our 40cm^2 concrete pavers were scored into 10cm^2 quarters. We considered each quarter a separate colonization unit.

After a colonization period of 28 days (September 24), we retrieved half of the gravel and leaf bags from the West and Middle sites with 250µ mesh dip nets. We installed another set of 4 "fresh" of gravel bags and leaf bags at each of those locations. Using brushes, we cleared 2 quarters of each concrete paver surface (= 4 total/site) into 250 µ mesh dip nets. All collected materials were preserved in 70% ETOH and processed in the lab.

After an additional 28 days (October 22), all the mesh bags were removed (the remainder of those installed August 27* and and all those installed September 24) as described above. In addition, we brushed each quarter of each concrete paver*, preserved and processed the samples as described above.

Processing and Analyses:
Sample processing involved sieving each sample through 250µ netting and identifying macroinvertebrate morphospecies using a microscope. Arthropods and gastropods were identified to family or genus. Other invertebrates were assigned to higher taxa (Nematomorpha, Nematoda, Oligochaeta, Hirudinea). We analyzed our data with Ttests, one-way ANOVAs**, and Tukey HSD post-hoc tests. Macroinvertebrate biotic index (MBI) tolerance values (Tv) and sample MBI calculations ($MBI = \Sigma Tv/\Sigma N$) were used to compare water quality tolerances of taxa colonizing the three substrata (Barbour et al. 1999, Hauer & Lamberti 1996, Hilsenhoff 1988).

*The 8-wk samples were not processed.
**Some data were log-transformed to meet ANOVA criteria of normality and HOV.

Figure 1. Our study site is located between the communities of Orange City and Alton in NW Iowa. The site is surrounded by farmland that is being rapidly converted to residential developments.

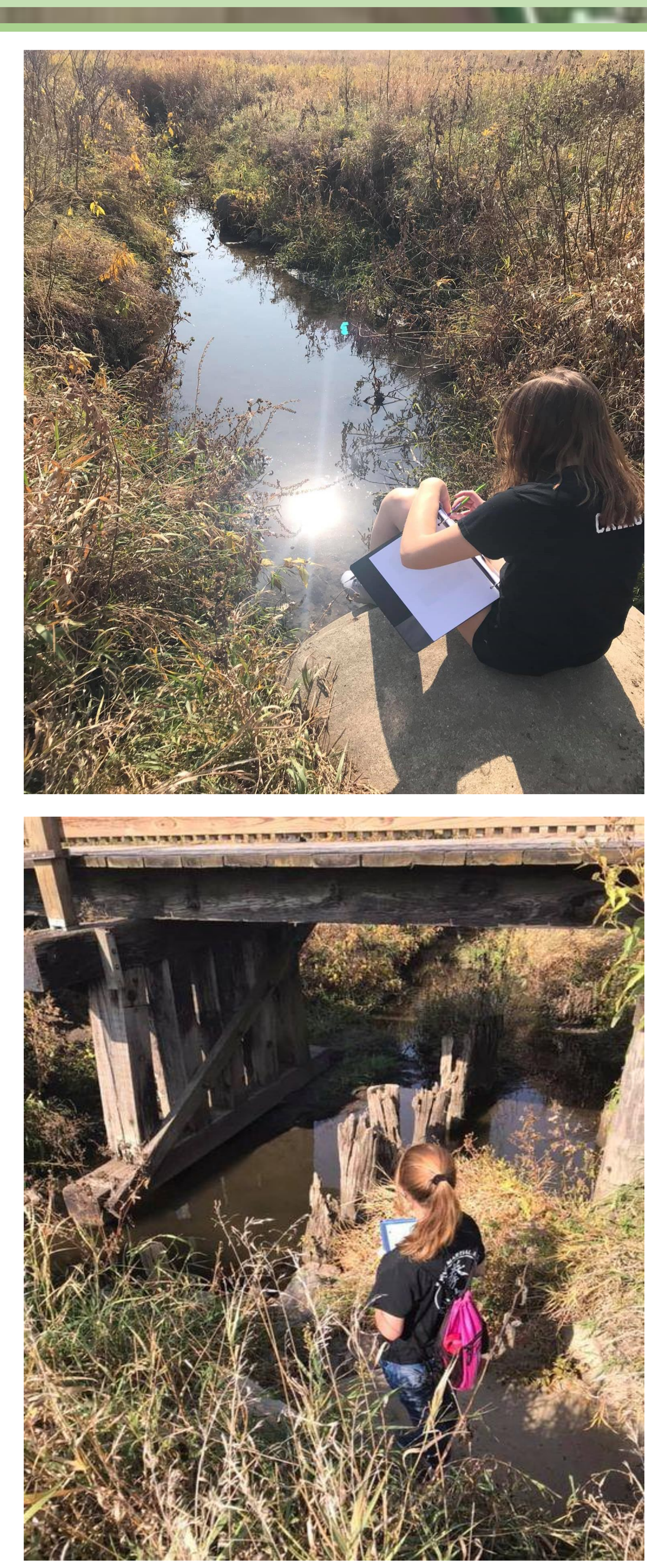

Figure 2. Views of the Middle Site.

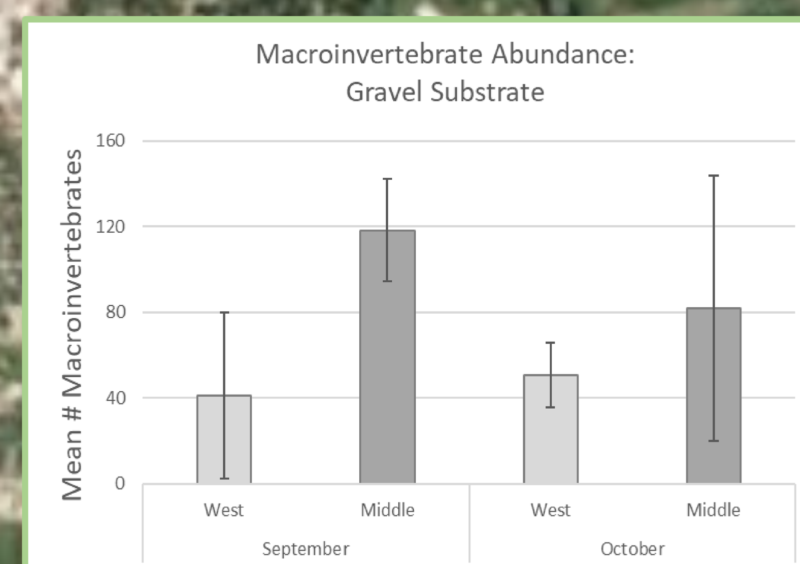

Figure 3a.

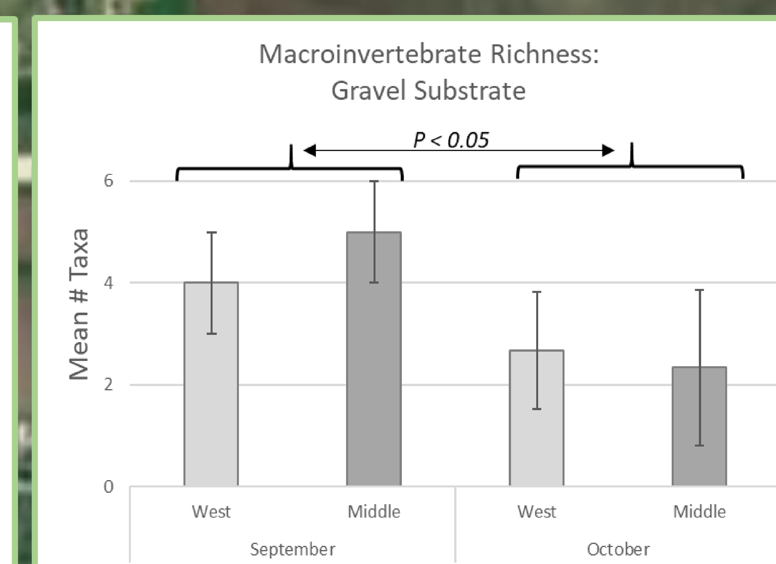

Figure 3b.

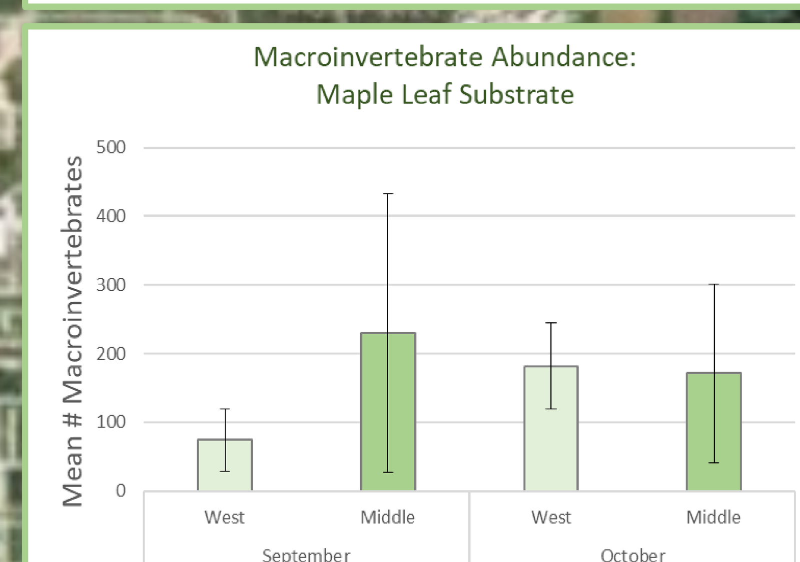

Figure 4a.

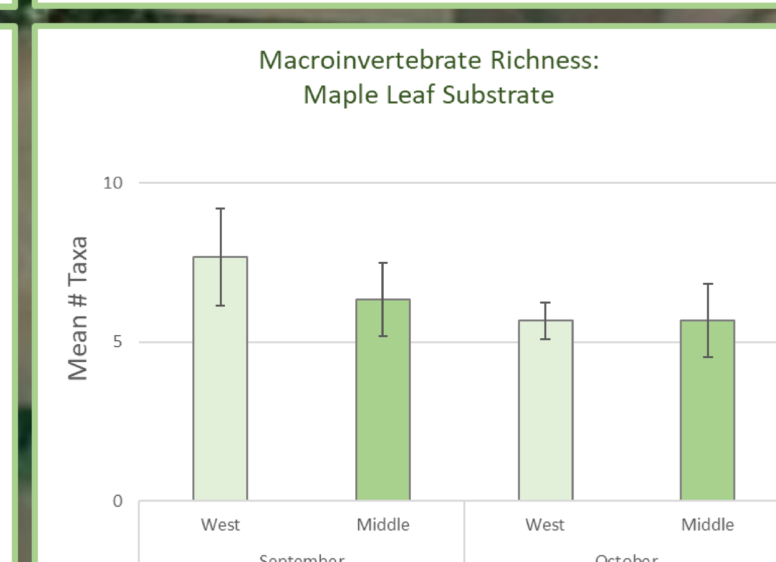

Figure 4b.

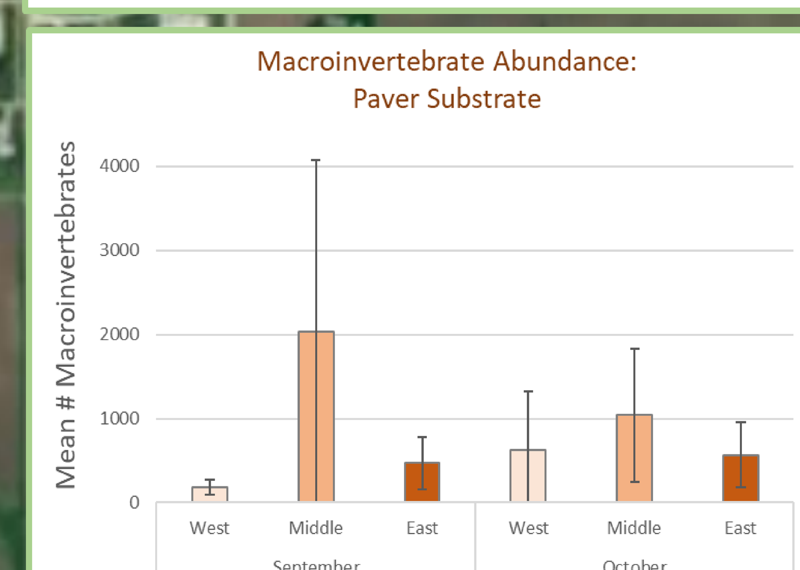

Figure 5a.

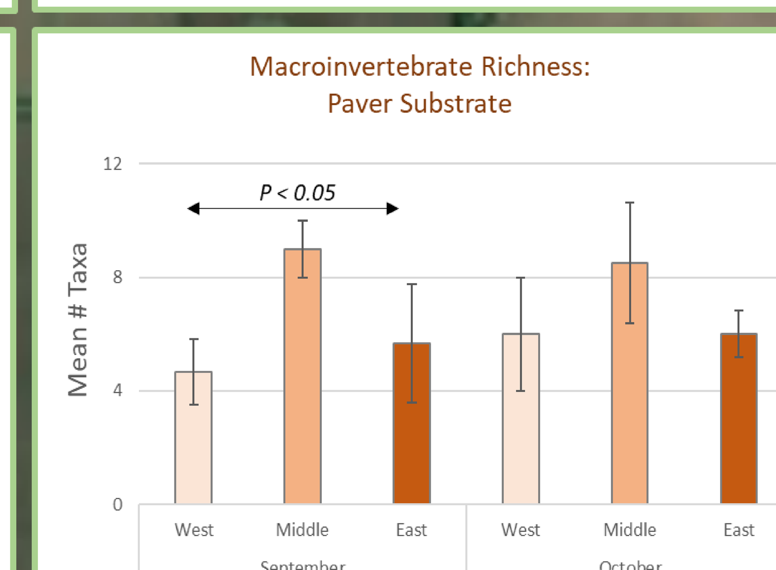

Figure 5b.

CONCLUSION

Sioux County is heavily dependent on agriculture. Often, farmers plow right up to creek banks, forgoing buffer strips in order to get a few more rows of corn. As a result, most Sioux County streams are heavily degraded and do not readily attract the attention of ecologists. However, it is important to gather baseline data from even heavily degraded habitats if we want assess ongoing negative impacts for comparison with future landscape changes. Orange City is experiencing a boom of residential growth on former farmland. Much of that growth is adjacent to our study creek. Will this watershed transition result in increased degradation of this small stream or improved habitat quality? We now have two years of baseline data that will help future researchers answer that question. In addition, as we compare our results with the 2018 study, we see that it is important to address how major hydrological events affect our study site.

RESULTS AND DISCUSSION

Based on our initial survey of the sites, macroinvertebrate richness ranged from 3 to 10 taxa and the taxa were indicators of "very poor" water quality (Hilsenhoff 1988). These results are comparable to a previous study of the site (Tarchione et al. 2019).

Due to the constraints of space, our physical/chemical data are not displayed on this poster and only significant p-values are shown in the figures. We are happy to provide a handout to anyone interested in our physical/chemical data and/or the details of our statistical analyses.

When considering substrate types separately, abundance and richness *generally* did not differ significantly with site or with month (Figures 3a – 5c). However, overall richness in gravel was significantly higher in September than October (Figure 3b) and significantly higher on East vs. West pavers in September (Figure 5b). Further investigation will be required to determine if these differences are the results of biologically meaningful patterns.

We hypothesized that richness and abundance would be highest at the Middle site because it is immediately downstream from a small conservation easement. Although the data indicate that richness and abundance were *generally* higher in at the Middle site, they were not significantly higher (Figures 3a, 3b, 4a, 5a, and 5b)

Because there were few significant differences between sites within each substrate type, we grouped the data to compare differences in abundance and richness between substrate types overall (Figures 6a- 7b). Abundance was much higher on pavers than the other substrata, however, the data were so variable that we only saw a significant result in one case (Figure 7a). Richness was also highest on pavers, significantly higher than gravel and leaf substrata in September and than gravel substrate in October (Figures 7a and 7b). Because the pavers have low habitat heterogeneity, these results are the opposite of what we hypothesized. They also differ from the results observed 2 years ago (Tarchione et al. 2019).

We believe that the lack of heavy rainfall during our study resulted in the build up of silt on the pavers (Figure 8). Silt-loving taxa such as bloodworms, oligochaete worms, copepods, and seed shrimp were much more abundant and diverse on the pavers. During the 2018 study, a historic rain event cleared the silt from the pavers resulting in significantly lower abundance and richness compared with the more protected gravel and leaf substrata.

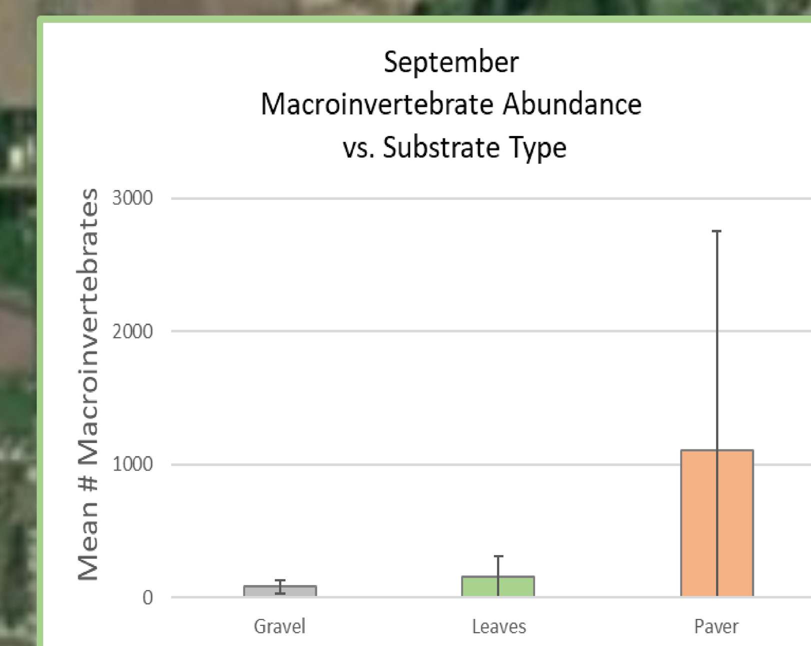

Figure 6a.

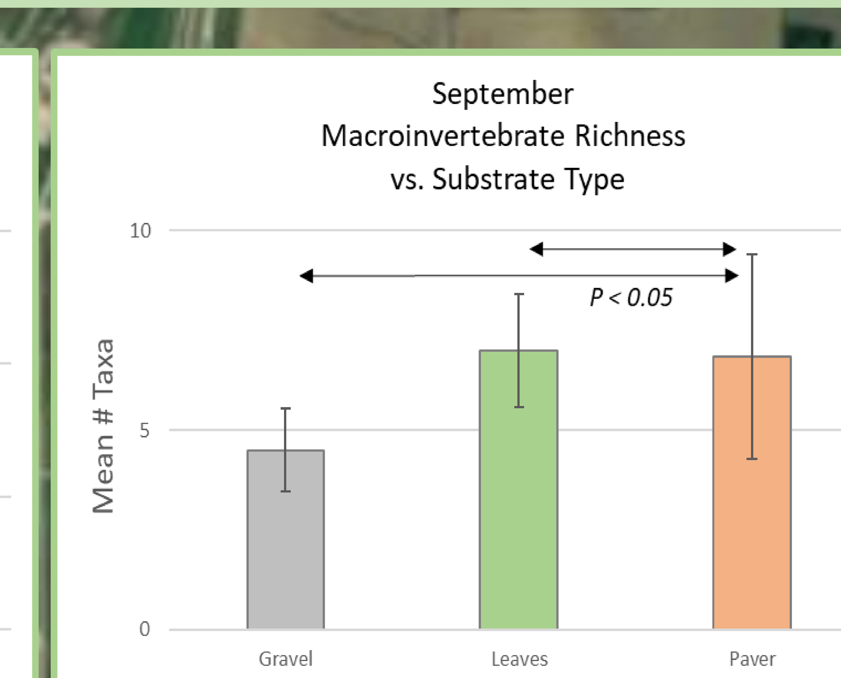

Figure 6b.

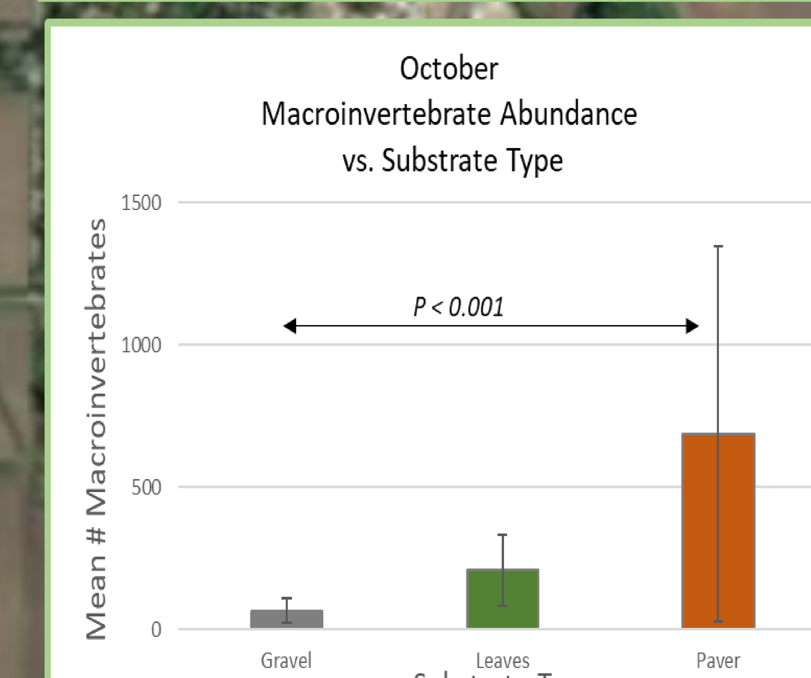

Figure 7a.

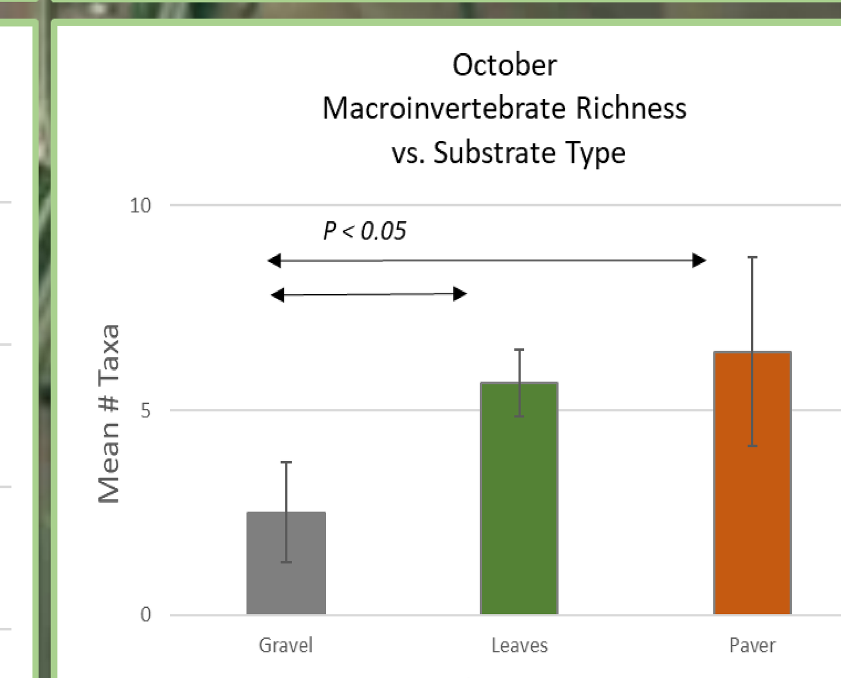

Figure 7b.

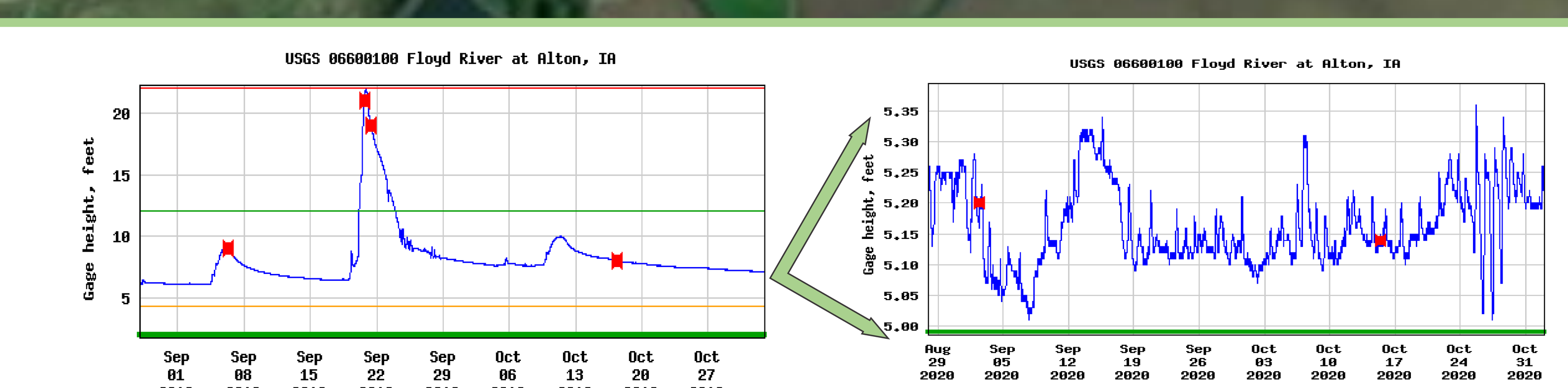

Figure 8. Comparison of gage heights (indicators of flow) in the nearby Floyd River during the 2018 and 2020 study periods. Our study stream is a direct tributary to the Floyd River. The flow event of September 22, 2018 was historically high. Note differences in gage height scales.

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Tarchione, S. et al. (2019) Substrate Colonization by Macroinvertebrates in a Degraded Low-Order Stream.
Poster presented at the Iowa Academy of Sciences April 2019 Meeting.

Image Sources: Midge larvae https://commons.wikimedia.org/wiki/File:Larve_de_chironome_(Tribu_Tanytarsini).jpg; Satellite Image https://www.google.com/earth/, Floyd River gage heights https://waterdata.usgs.gov/nwis/uv?site_no=06600100