Proceedings of The National Conference
On Undergraduate Research (NCUR) 2016
University of North Carolina Asheville
Asheville, North Carolina
April 7-9, 2016

Visual Assessment of Cullowhee and Richland Creek to Assess Habitat Quality

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Abstract

Increased urbanization efforts have had multiple detrimental effects on the habitat quality of streams throughout the United States. The Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) and the United States' Department of Agriculture's Stream Visual Assessment Protocol (SVAP) were used to assess the habitat quality of Richland and Cullowhee Creek, in an effort to 1) compare the two habitat assessment protocols and 2) compare habitat quality between streams and between urban and rural areas. Four total sites were surveyed: an upstream rural area and a downstream urban area at each of the stream locations. There were significant differences with the SVAP protocol between rural and urban sites, as well as an overall difference between Richland and Cullowhee Creek. No significant differences were found in the RBP scores. Variances in protocol methods can be attributed to different scores among the observers and the habitat features scored. Cullowhee Creek had healthier amounts of habitat complexity and habitat vegetation, while Richland Creek has suffered from increasing urbanization and removed riparian vegetation.

Keywords: Creeks, Rapid Bioassessment Protocol, Stream Visual Assessment Protocol

1. Introduction

Streams are complex ecosystems where biological, chemical, and physical processes interact with changes in any characteristics, causing cascading effects throughout the system[13]. Growing bodies of literature document substantial alterations in channel morphology, flow patterns, water quality, and biotic communities due to watershed urbanization[13]. A watershed is an area of land that contains sets of streams that all eventually drain into a larger body of water. Consequences of increased urbanization include factors such as increased erosion, reduction in large woody debris, excessive amounts of sedimentation, and channel widening or destabilization[13]. Reductions in habitats spell trouble for river ecosystems, as these systems benefit from increased structural complexity, which is provided by fallen trees in the channel, overhanging vegetation, pools, and riffles[13]. This loss in complexity reduces crucial habitats for species that often inhabit these creeks. These conversions of landscapes from indigenous cover to urban areas have significant detriments to the biological communities present. Biological communities in the ecosystem incorporate effects of varying stressors, providing a measure of the effects and their impact as a whole[2]. For example, macro-invertebrate assemblages give helpful site-specific impacts of local conditions, due to their lack of movement or tiny migration patterns—not to mention, they serve as primary food sources for other species like fish[2]. Fish on the other hand, give a better look at long-term effects and have broader habitat conditions, as they tend to live longer and are always on the move. Fish not only provide food for mammals such as birds, but they also provide food for humans, making fish important for assessing contamination[2]. Contamination in fishes often comes from chemical pollutants such as manure, ammonia, organic wastes, phosphorus, and acids from mining and industrial activities, as well as

various pesticides in drain water[13]. As watersheds continue to become developed, fish density as well as species richness has been reported to fall, as areas can no longer support diverse faunas[11]. What can be done to combat this?

Without proper test methods, evaluating the habitat quality of streams would be nearly impossible with all the factors present, which is where the aforementioned protocols come into play. The first protocol performed in this experiment was the EPA's Rapid Bioassessment Protocol (RBP). This protocol is used by various state water resource agencies, such as the Florida Department of Environmental Protection, and is best used for detecting aquatic life impairments and assessing the severity of the problems present[2]. The RBP method was done through assessing 10 different habitat attributes, which include: epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles/bends, bank stability, vegetative protection, and riparian vegetative zone width. The second protocol used in this experiment was the USDA's Steam Visual Assessment Protocol (SVAP). This protocol is often used by conservationists with minimal biological or hydrologic training, and provides an assessment based on physical conditions at the site[13]. The second protocol uses 12 different habitat indicators which include: channel condition, hydrologic alteration, bank stability, riparian zone, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, invertebrate habitat, canopy cover, and riffle embeddedness.

The two areas of interest for this study were Cullowhee and Richland Creek, both of which are located in Western North Carolina. Cullowhee Creek is located in Cullowhee, within Jackson County, NC and runs straight through the campus of Western Carolina University in many areas. Physical alterations to the stream channel caused changes in the channel structure, but in 2005, restoration efforts were made to return a more nature flow and structure to the stream[1]. Impacts from recent efforts to urbanize in Cullowhee and their effect on the stream remain to be seen. Richland Creek runs straight through the town of Waynesville, in Haywood County, NC. This watershed contains 43,638 acres supporting the town of Waynesville, many industries, agriculture, and flows through the most heavily portioned of the county on its way to Lake Juanaluska[10]. Along the river reside many residential houses, as well as the largest Epsom Salt factory in North America. Using the EPA's Rapid Bioassessment Protocol and the USDA's Stream Visual Assessment Protocol scoring methods, the research compared the quality of Richland and Cullowhee creek to determine which stream was in a better condition.

2. Methods

2.1. Protocol

The EPA's RBP and the USDA's SVAP were the two assessment protocols used for this experiment. The EPA's Rapid Bioassessment Protocol scores on 10 different factors with a score of up to 20 for each category with higher scores equaling healthier conditions. These scores are based upon four different condition categories: optimal (20-16), suboptimal (15-11), marginal (10-6), and poor (5-0). The USDA's Stream Visual Assessment Protocol scores on 12 factors (with a score of up to 10) that are then divided by the total score achieved by the assessments. Scores for each factor generally follow a 10, 7, 3, 1 format with less room for user interpretation. The overall scores also fall into four categories to provide an idea of the habitat: <6 (poor), 6.1-7.4 (fair), 7.5-8.9 (good), and >9.0 (excellent).

2.2. Surveying

For this study, two different sites were analyzed (four total locations) at both Cullowhee and Richland Creek. One site at Richland and Cullowhee Creek was located in an urban area, where a downstream pass was made. The other location for both areas was a rural area, where an upstream pass was made. To ensure accurate assessments from each of the four surveyors, the surveyors waded 100m upstream at each site, observing the habitat and taking mental notes of factors on the protocols. After wading the 100m pass, the surveyors returned downstream, completing the RBP and SVAP surveys. four different surveyors allowed for replication of the data, which accounted for user bias. After completion of the passes, the four sites were then compiled together into an Excel spreadsheet, where a statistical R program was used to perform an ANOVA.

2.3. Description Of Sites

Figure 1. Western Carolina University Park (Urban Downstream Cullowhee Creek) latitude/longitude: 35.310781, -83.185095[7]

This area is where previous restoration efforts to restore the health of the stream occurred. Areas of previous channelization are still present with areas of human activity on either side of the creek apparent. To the left, there is the park, a softball field, and further down a parking lot and to the right there is sports field as well as a track field.

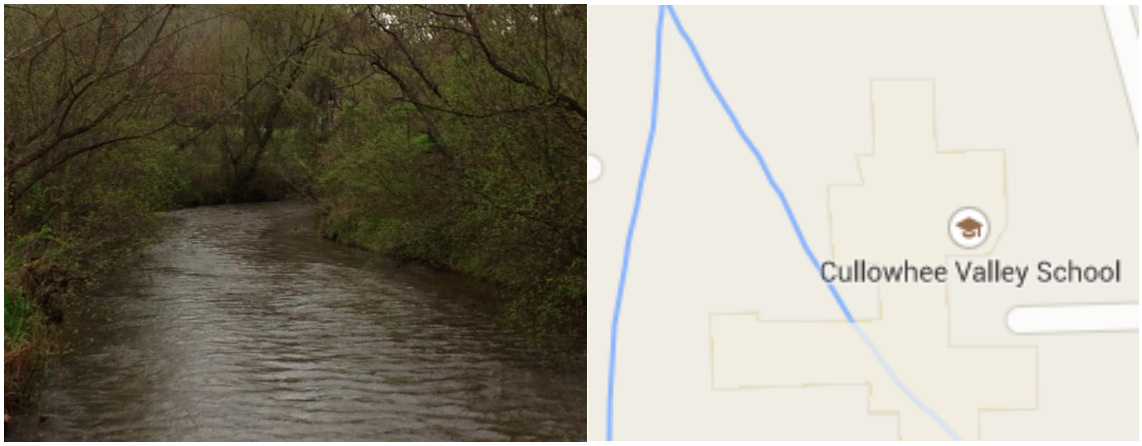

Figure 2. Cullowhee Valley School (Rural Upstream Cullowhee Creek) latitude/longitude: 35.294837, -83.183552[4]

This site was more removed from the effect of urbanization with more natural vegetation present on both banks as well as a natural stream structure. The right bank had a small baseball field past the riparian zone, while the left bank showed some paths in the forest from where people came to fish at the area.

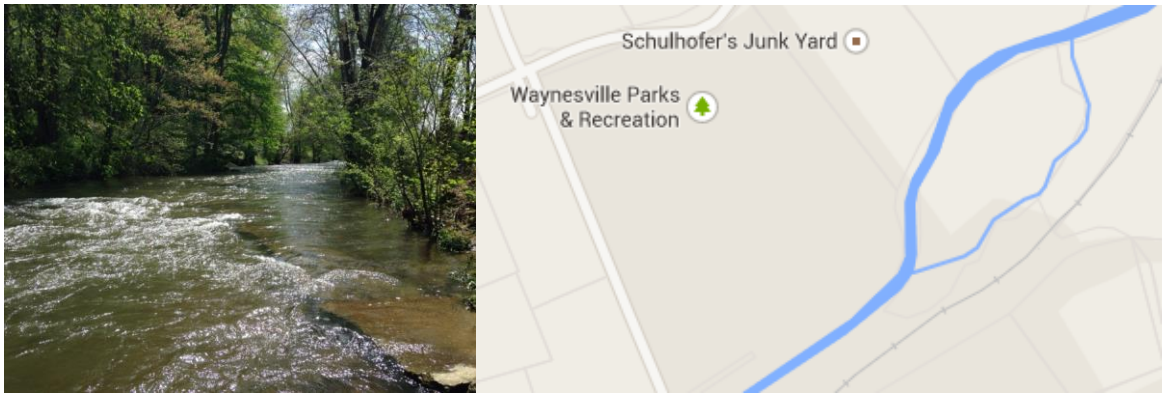

Figure 3. Waynesville Recreation Park (Urban Downstream Richland Creek) latitude/longitude: 35.506022, -82.978342[6]

This site had evident appearances of human activities all around. The left bank had a park with constant human activity extending the entire pass and the right bank had a railroad area causing degradation in the riparian zone.

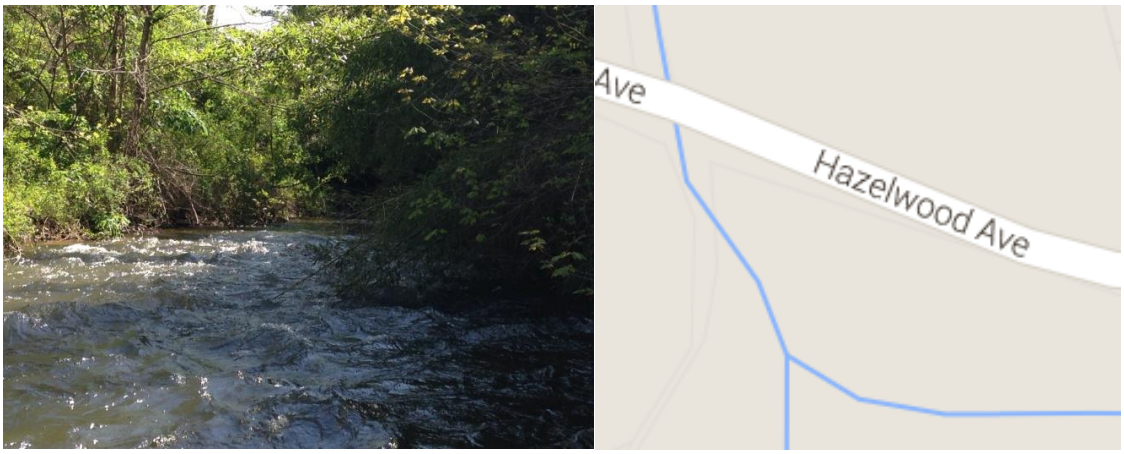

Figure 4. Hazelwood Rd. (Rural Upstream Richland Creek) latitude/longitude: 35.479021, -83.007986[5]

This was one of the healthier sites present in the city of Waynesville. Both sides of the bank were heavily vegetated with little to no human impact overall. There was a fast flow of water present with no areas of slow moving water present in the entire 100m pass.

3. Results

In order to analyze the date from the USDA's SVAP and the EPA's RBP, the statistical R program was used to perform an ANOVA test from the four sites. Correlations between Cullowhee Creek and Richland Creek help determine which stream was in healthier condition and which creek is in danger of losing biota. The EPA's Rapid Bioassessment Protocol showed no significant relation, $p=0.3377$ between rural and urban areas for Cullowhee and Richland Creek. The RBP also shows no significant relationship between either of the two streams, $p=0.8686$.

Table 1. EPA's RBP ANOVA. No significant difference between either of the data points

ANOVA for EPA RBP Scores:				
Response: Score				
Df	Sum Sq	Mean Sq	F value	Pr(>F)
Cullowhee and Richland Creek 1	7.6	7.563	0.0286	0.8686
Urban and Rural Sites 1	264.1	264.062	0.9972	0.3377
Stream: Urban 1	3.1	3.063	0.0116	0.9161
Residuals 12	3177.8	264.813		

Using the statistical R program to perform another ANOVA test for the USDA's Stream Visual Assessment Protocol showed significant results. There were significant differences, not only in the comparison between rural to urban, $P<0.0001$, but there were also significant differences between Cullowhee and Richland Creek, $p=.004$.

Table 2. USDA's SVAP ANOVA. Significant differences in rural vs. urban, as well at Cullowhee and Richland Creek

ANOVA for USDA SVAP Scores:					
Response: Score					
Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Cullowhee and Richland Creek 1	1.3053	1.3053	12.3904	0.004223	**
Urban and Rural Sites 1	11.1723	11.1723	106.0515	2.61E-07	***
Stream:Urban 1	0.0068	0.0068	0.0646	0.80366	
Residuals 12	1.2642	0.1053			

The difference in the scoring patterns between the two assessment protocols is apparent when the two protocols are found to have no significant relationship, $p=.3755$.

Table 3. Correlation between EPA and USDA protocol

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
EPA vs. USDA	1	0.7765	0.77651	0.838	0.3755
Residuals	14	12.9721	0.92658		

Box plots were also made, again showing now correlation between the EPA's Rapid Bioassessment Protocol, while the USDA's Stream Visual Assessment Protocol had differences in both the streams and the rural versus urban area again.

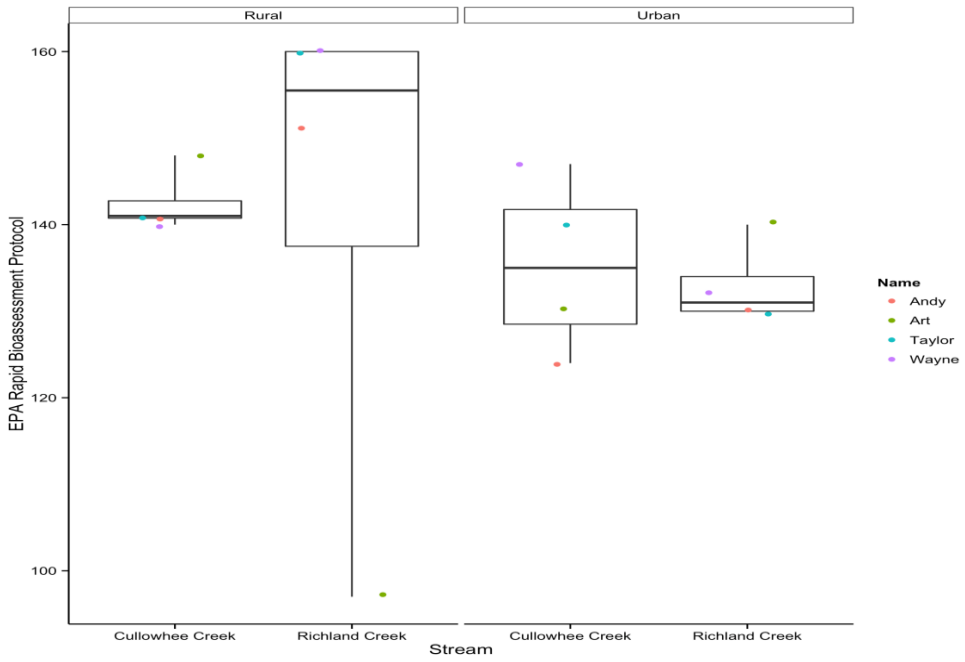

Figure 5. Box Plot of EPA's RBP. No correlation to differences in the streams with this method

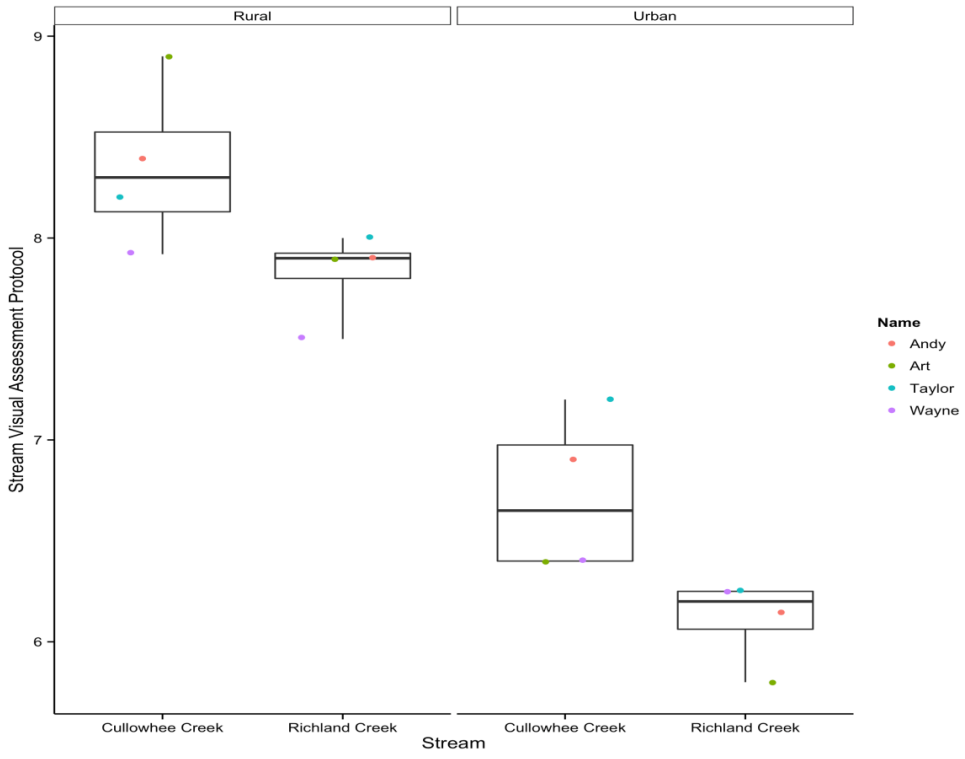

Figure 6. Box plot of USDA's SVAP. Significant differences in rural vs. urban present, as well as differences in the stream

4. Discussion

One main difference that stands out in this study is that Table 1, Table 3 and Figure 5 show no correlation between the EPA's RBP and the USDA's SVAP. There are a number of different factors that may lead to this lack of correlation in the tests. For starters, the USDA's SVAP has 12 categories that are only scored with four possible scores for each (10, 7, 3, 1). The EPA's RBP only has 10 categories, but allows the surveyor a much larger range to score with 20 possible scores (1-20). Another difference in the scoring surveys is that the Rapid Bioassessment Protocol offers scoring for left and right banks on three factors: bank stability, vegetative protection, and riparian vegetative zone width. The Stream Visual Assessment Protocol only offers one score for these factors, leaving less interpretation to the user, which results in less variance in the scores. Of crucial importance is the difficulty behind each protocol. The RBP is often used alongside management framework often used by seasoned biologists, in an effort to prioritize water quality problems for precise assessments, especially in documenting environmental recovery[2]. The SVAP is a simple, comprehensive assessment, often used by novice researchers, giving a nice first approximation of stream condition, as well as putting a focus on certain parts of an ecosystem that may need help[13]. The efficiency of the SVAP is shown in Figure 6 where significant differences in Cullowhee and Richland Creek are demonstrated as well as in the urban and rural sites, while Figure 5 demonstrates the inefficiency of the RBP protocol in our assessment, as it produced no results. The insignificant results of the EPA Rapid Bioassessment Protocol may be related to the higher amount of training that surveyors normally have when using the protocol. The four surveyors for this experiment were all novice biologists, who had little experience surveying streams. Their naivety caused judgment calls on certain factors to be difficult to make and may have often lead to an incorrect score. To ensure a lack of bias, the data was redone for Figure 5 without the 97 score outlier and the results still remained insignificant with no correlation.

The USDA's SVAP demonstrated a significant difference in habitat quality between Richland and Cullowhee creek in Figure 6. The results of the survey indicate that Cullowhee Creek is in healthier shape due to the presence of more woody debris, greater habitat complexity, stable banks, pools, and more species diversity present in the rivers. The presence of woody debris has been found in multiple studies to increase the macro-invertebrate species present, which positively affects the surrounding ecosystem[3]. Richland Creek has suffered from heavy amounts of urbanization, where mounting economic pressures to develop the area have increased with not enough area to sustain the diverse faunas present[11]. The removal of the riparian vegetation, at areas like Waynesville Recreation Park, has reduced the available organic matter weakening the strength of the channel to filter out pollutants, sediments, and other harmful runoffs[12].

Multiple researchers have conducted similar surveys and studies in the field of stream ecology. Violin et al. compared the biological and physical structure of different sets of forested, urban restored, and urban impaired streams[12]. The study found significant differences in the amount of lower riparian canopy cover between degraded and restored areas, with restored streams being biologically similar to urban area[12]. This is similar to our data as restoration efforts have been made in Richland Creek, but the heavy amount of degradation has impeded those efforts. Jernigan and Liles found the helpfulness of the SVAP in pinpointing problems within the water quality as well as noting the importance of habitat complexity[12]. The study also addresses the subjective nature of the protocol as non-experts make uneducated guesses on factors, such as water appearance, causing variation in scores[12]. This is congruent with our study where guesses have a significant impact on the total scores for each creek site.

Future assessments using the EPA's Rapid Bioassessment Protocol should put a bigger emphasis on training in an effort to ensure accurate assessments. The simplicity of the USDA's Stream Visual Assessment Protocol allowed us to document significant differences in the habitat quality of Cullowhee and Richland Creek as well as the rural and urban sites. Though Richland Creek has heavier amounts of urbanization, Cullowhee Creek also suffers from humanities efforts to expand which can have detrimental effects on the channel, erosion, instream cover, pool habitat, biological communities, the hydrology and that's not even the half of it[13]. The results of this survey can pinpoint exact problems in each stream, allowing researchers to come up with proper restoration methods that can help to reduce the impacts of urbanization.

5. Acknowledgements

This project could not have been completed without the collaborative effort of the research team, so thanks to Arthur Bien, Andy Myers, and Taylor Payne for assisting me in the surveys. Special thanks to Dr. Thomas Martin in assisting the team with research methods, meeting with us throughout the semester, and lending an ear when needed.

6. References

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