Ecological Assessment of the Illinois River Watershed

February 2022

Thank you to our current Ecological Assessment partners.

And thank you to past assessment partners who have made this multi-year study possible.

We would like to express our appreciation to the many contributors of this report including Dr. Nicole Hardiman, Justin Nachtigal, Matt Taylor, Candice Miller, the staff at Grand River Dam Authority (GRDA) water quality laboratory, and the many individuals who volunteered their time to make this research possible current and past. We also want to thank the landowners throughout Oklahoma and Arkansas who allowed us to access the river and its subwatersheds across their properties.

Mission
IRWP works to improve the integrity of the Illinois River through public education, community outreach, and implementation of conservation and restoration practices throughout the watershed.

Vision
The Illinois River and its tributaries will be a fully functioning ecosystem, where ecological protection, conservation, and economically productive uses support diverse aquatic and riparian communities, meet all state and federal water quality standards, promote economic sustainability, and provide recreational opportunities.

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Introduction

The Illinois River Watershed (IRW), located in Northwest Arkansas and eastern Oklahoma, includes just over 1 million acres, one of the fastest growing metropolitan areas in the country. The IRW is also home to Arkansas' and Oklahoma's top producing counties for chicken production (Benton and Delaware County) (USDA, 2021). Benton County, Arkansas is also the top producer in the state for cattle and calves (USDA, 2021). The watershed is extremely ecologically diverse, containing extensive cave systems, upland and lowland prairies, oak-hickory dominant forests, and the northern and western most portions of the Boston Mountains. While the watershed is mostly rural, consisting of forest and pasture lands, the development of the Fayetteville-Springdale-Rogers metropolitan area is placing additional environmental pressure on the watershed as the headwaters of several major tributaries are located in this area. In fact, many of the towns in the region were first established due to the presence of the many springs and creeks within the IRW. Important management considerations within the Illinois River Watershed include erosion and sedimentation, nutrient loading, and bacteria impairments.

The watershed is considered a priority subwatershed by the States of Arkansas and Oklahoma, as well as the Cherokee Nation, and it is monitored regularly by many state and federal agencies. However, monitoring locations are widely dispersed geographically, making management decisions challenging at the subwatershed scale based on monitoring data alone. The three main goals for this project were:

1. Gain an improved ecological understanding of the entire watershed.
2. Provide long-term trend analysis of watershed condition at small geographic intervals.
3. Identify priority areas for management activities such as education and outreach campaigns, as well as conservation and restoration projects.

We believe this report, its findings, and management recommendations can assist city and county elected officials and relevant staff, business leaders, and interested landowners to make decisions on land use and management decision, stormwater management, and natural resource issues across the watershed.

The project assessed in-stream, streambank, and riparian ecological condition and macroinvertebrate diversity in eight subwatersheds (four in Arkansas and four in Oklahoma). All subwatersheds are designated as impaired by each State's Departments of Environmental Quality. The four subwatersheds in Arkansas have previously been identified as high contributors to sediment and nutrient loading in modeling studies. In 2018 and 2019, IRWP partnered with local schools' Environmental and Spatial Technology (EAST) programs to assess twenty-one locations in April, August, and November of each year. In 2020 and 2021, IRWP partnered with Oklahoma Conservation Commission's Blue Thumb staff and volunteers to assess twelve locations during the same months. This report summarizes findings from the first four years of study. The assessment in Arkansas will be repeated in 2022 and it is the goal of the program to assess the same Arkansas sites in even years and Oklahoma sites in odd years on an on-going basis.

Methods

Stream Habitat Assessment:

- Utilized EPA's Volunteer Stream Monitoring: A Methods Manual (publication number EPA 841-B97-003). Section 4.1: Stream Habitat Walk.
- 300 feet stream reach subdivided into four, 75-foot sections.
- Each 75-foot section was observed by standing at the downstream-most end and looking upstream.
- For the purposes of data analysis, percent observations for each site were averaged across sections, then average across years.

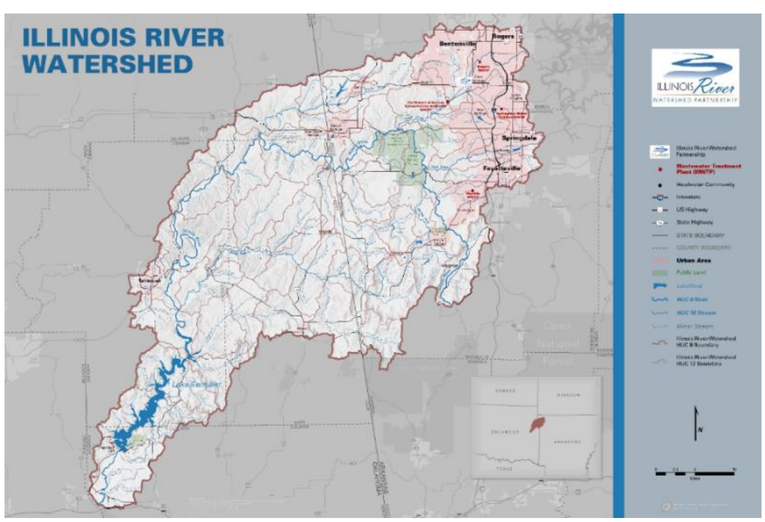
Macroinvertebrate Diversity

- Utilized EPA's Volunteer Stream Monitoring: A Methods Manual (publication number EPA 841-B97-003), section 4.2: Streamside Biosurvey.
- Sampling consistent of a composite of three, three-foot riffle locations across the entire 300 foot stream reach.
- Macroinvertebrate identification based on Izaak Walton League of America – Stream Insects and Crustaceans.
- Macroinvertebrate score calculated using Arkansas Game and Fish Commission's Stream Team method.
- One score was generated for each season and, for the purposes of data analysis, averaged across years.

Statistical Analysis:

- All analyses were performed in Microsoft Excel.
- Compared variables included macroinvertebrate diversity, composition of stream bottom, streamside cover, surrounding land use, and types of algae present.
- Regression analysis was used to examine relationships between each of the above habitat variables and diversity scores.
- T-tests were used to compare variables between Arkansas and Oklahoma.

Purposive sampling was used in selection of sites with a focus on diverse land use, land cover, subwatershed integrity, and other characteristics. Below is a map of the Illinois River Watershed.



Summary of Findings

- Oklahoma scored a higher average macroinvertebrate diversity score (24) than Arkansas (16) (Figure 1).
- Macroinvertebrate diversity was significantly higher across all Oklahoma sites when compared to Arkansas. (Figure 2)(OK sites: Barren, Caney, Flint, Town. AR sites: Clear, Muddy, Sager, Moore's).
- In Arkansas, the sites with the lowest diversity scores were found in Muddy Fork and Clear Creek subwatersheds. The site with the highest diversity score in Arkansas was also found in Clear Creek subwatershed (Figure 3).
- In Oklahoma, the site with the lowest average diversity score was found in Barren Fork and the site with the highest average diversity score was found in Flint Creek (Figure 3).

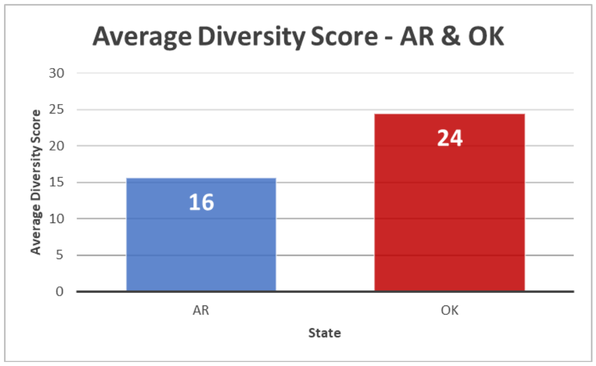


Figure 1: Average macroinvertebrate diversity in Arkansas and Oklahoma

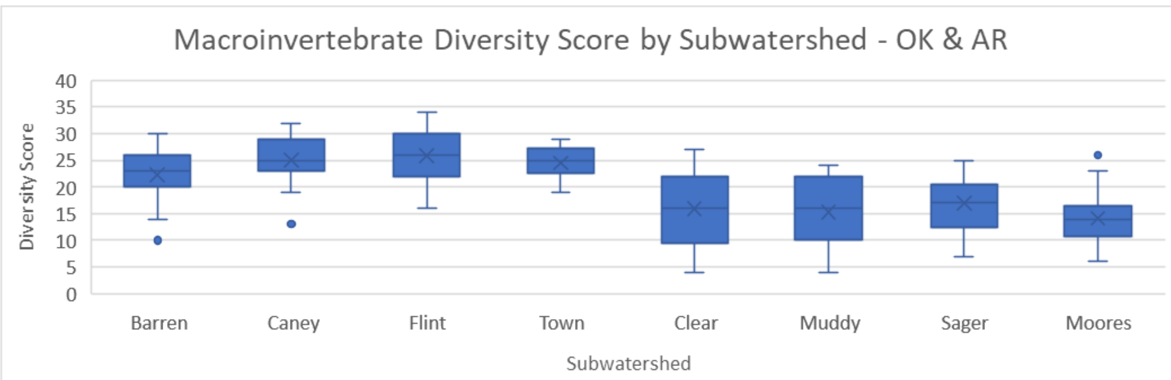


Figure 2: Average macroinvertebrate diversity across all subwatersheds.

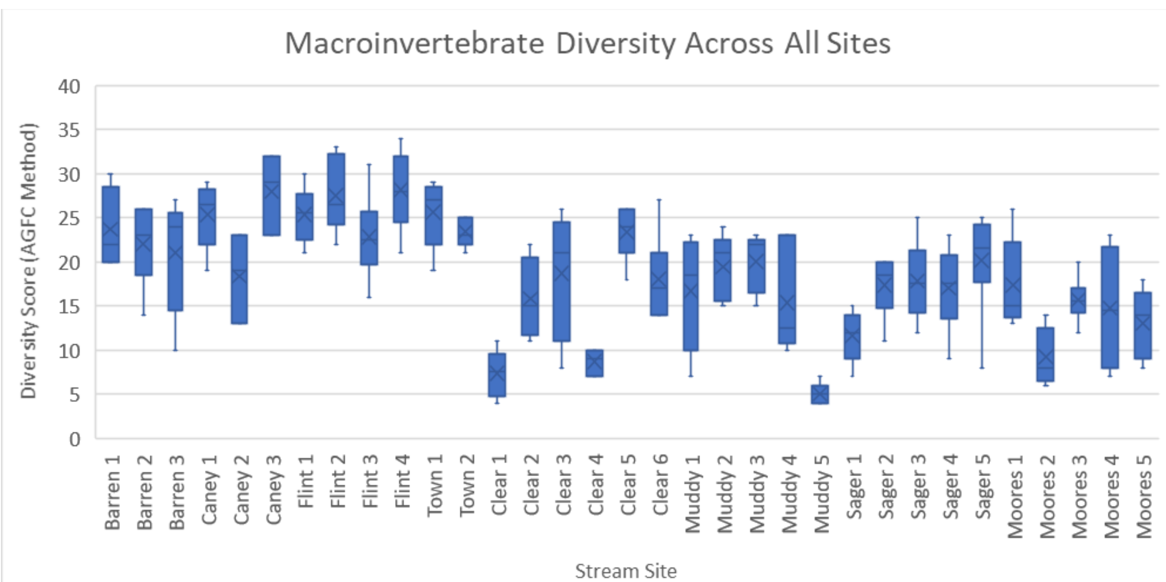


Figure 3: Average macroinvertebrate diversity across all sampling sites.

When examining relationships between diversity scores and habitat parameters:

- All significant relationships were weakly related (Table 1). This is likely due to the limited amount of data taken causing a spread in the analysis. It is expected that as our data set becomes more robust, we will see a strengthening relationship.
- There were positive relationships between diversity and presence of gravel and cobbles within the streambed. There were negative relationships between diversity and presence of silt, clay, and mud within the streambed, filamentous algae in the water column, and presence of trees along the streambank banks (Table 1).
- Due to the number of significant relationships, we have chosen to focus on the three significant streambed types for subwatershed analyses. Those are: gravel, cobbles, and silt/clay/mud (fig 4, 5, 6).
- The positive relationships between gravel, cobbles, and macroinvertebrate diversity is expected as these organisms use open spaces between substrates as habitat for protection and reproduction. The negative relationship with silt, clay, and mud is also expected. As a consequence of erosion, small soil particles can impact aquatic organisms' ability to obtain oxygen. Additionally, these sediments fill open spaces between rocks that are important to these organisms' survival.

For purposes of this report and its findings, management recommendations focus on reduction of silt, clay, and mud from the immediate site, as well as from upstream land uses (which presumably contribute silt, clay, and mud to the sampling site).

Table 1: Regression analysis of all parameters considered in the EcoAssessment.

		Relationship to Diversity		
		Strong or Weak?	Significant?	Positive or Negative?
Algae	Slime Coating	Weak	Yes	None
	Filamentous	None	Yes	None
	Clumps or Mats	None	No	None
	No Algae	None	Yes	None
Streamside Cover	**Trees**	**Weak**	**Yes**	**Negative**
	Bushes/Shrubs	None	Yes	Negative
	Tall Grasses	None	Yes	Positive
	Lawn	None	No	None
	Boulders/Rocks	**Weak**	**Yes**	**Positive**
	Gravel/Sand	**Weak**	**Yes**	**Positive**
	Bare Soil	None	No	None
	Pavement/Structure	None	No	Negative
Land Use	Residential	None	No	None
	Roads	None	Yes	None
	Construction	None	No	None
	Agriculture	None	No	None
	Recreation	None	No	None
	Other	None	No	None
Streambottom	**Silt/Clay/Mud**	**Weak**	**Yes**	**Negative**
	Sand	**None**	**Yes**	**Positive**
	Gravel	**Weak**	**Yes**	**Positive**
	Cobbles	**Weak**	**Yes**	**Positive**
	Boulders	None	No	None
	Bedrock	None	Yes	None
Stream Habitat	**Percent Pool**	**Weak**	**Yes**	**Negative**
	Percent Riffle	**Weak**	**Yes**	**Negative**
	Percent Run	None	Yes	None
Riparian Cover	Trees	None	No	None
	Bushes/Shrubs	None	No	None
	Tall Grasses	None	Yes	Positive
	Lawn	None	No	None
	Boulders/Rocks	None	No	None
	Gravel/Sand	None	No	None

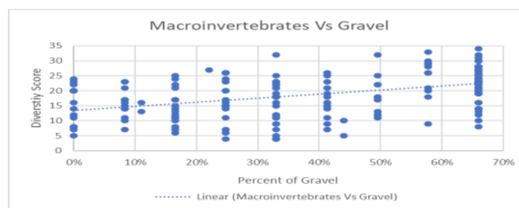


Figure 6: Linear regression model of the relationship between macroinvertebrates and the presence of gravel on the stream bottom.

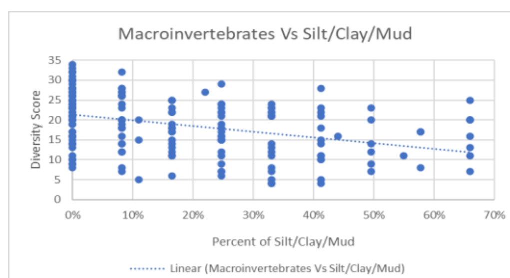


Figure 5: Linear regression model of the relationship between macroinvertebrates and the presence of silt/clay/mud on the stream bottom.

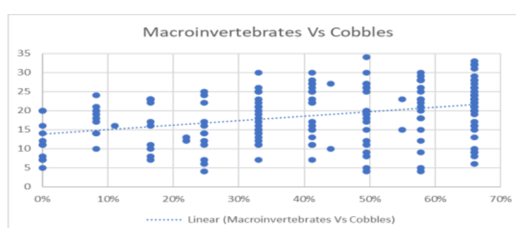


Figure 4: Linear regression model of the relationship between macroinvertebrates and the presence of cobbles on the stream bottom.

Oklahoma

The Oklahoma portion of the watershed is the focus of the 2021 EcoAssessment. The portion of the watershed located in Oklahoma makes up approximately 54% of the entire Illinois River Watershed (OCC, 2010). The Illinois River itself is designated as a State Scenic River and recognized as one of Oklahoma's most valuable water resources. In 1953, the Illinois River was impounded to form Lake Tenkiller for the purposes of flood control and hydroelectric power. Lake Tenkiller is considered to be one of the state's most aesthetically appealing lakes (OCC, 2010), promoting various recreational opportunities. The lake also serves as a drinking water source for many Oklahomans. The Illinois River in Oklahoma is listed on Oklahoma's Department of Environmental Quality 303d list of impaired waters for bacteria, dissolved oxygen, total phosphorus, and *chlorophyl a* (Lake Tenkiller).

Four tributaries to the Illinois River were observed in this study – Barren Fork, Caney Creek, Flint Creek, and Town Branch in Tahlequah. Continue reading below for our findings.

Barren Fork

The headwaters of Barren Fork begin in southern Washington county in Arkansas, however, most of this subwatershed is in Oklahoma. The Barren Fork drainage basin covers more land area than the main stem of the Illinois river and contains the largest piece of conserved land in the Illinois River Watershed – the J.T. Nickel Preserve (owned and managed by The Nature Conservancy). This 17,000-acre Preserve consists of uplands and lowlands including upland prairies, oak/hickory dominant forest, and sustainably managed pasture lands.

2020 Impairments (Oklahoma DEQ)

Phosphorus

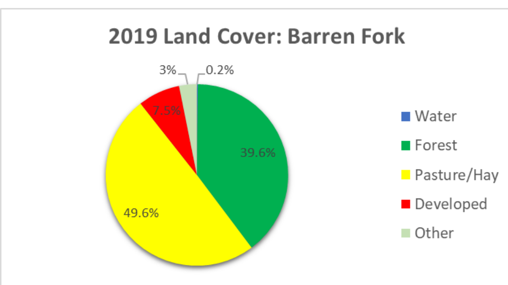


Figure 7: Land use in the Barren Fork subwatershed.

Table 2: Land use Change over time.

Barren Fork Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	57	52	50	-7
Forest	40	40	40	0
Developed	1	6	7	6
Water	0.3	0.1	0.2	-0.1
Other	2	3	3	1

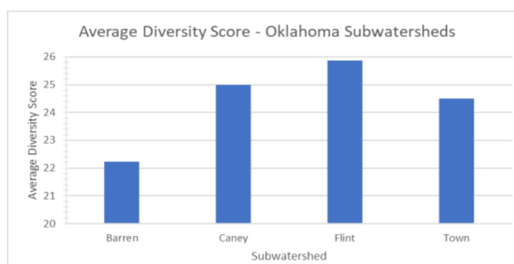


Figure 8: Average macroinvertebrate diversity in Oklahoma subwatersheds.

Data Summary

- The Barren Fork subwatershed underwent a 6% increase in developed land area from 1992 to 2019. This is likely caused by the conversion of pasture land (Table 2).
- Barren Fork continued to maintain the lowest macroinvertebrate score among the four watersheds surveyed in Oklahoma (Figure 8)
- Barren 3 was found to sustain the lowest median macroinvertebrate population and the greatest variation in population observations. Barren 2

sustains the highest median population (Figure 9)

- Barren 1 and 3 show increased diversity while Barren 2 shows decreased diversity from 2020 to 2021 (Figure 10)
- The presence of Silt/Clay/Mud stream bottom substrate was observed to be relatively low with a high amount of gravel and cobble – desirable habitat for macroinvertebrates (Figure 11).

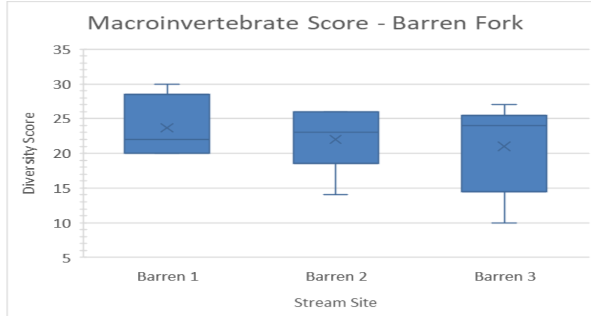


Figure 9: Average macroinvertebrate score across Barren Fork sites.

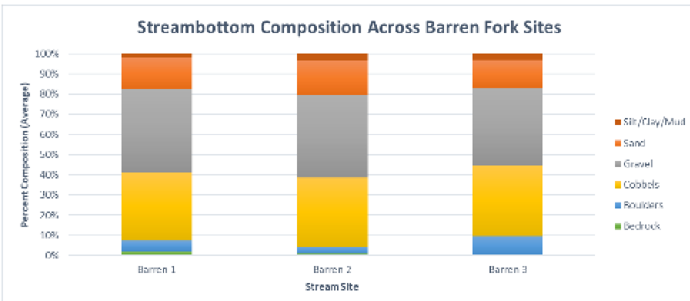


Figure 11: Streambottom composition in the Barren Fork

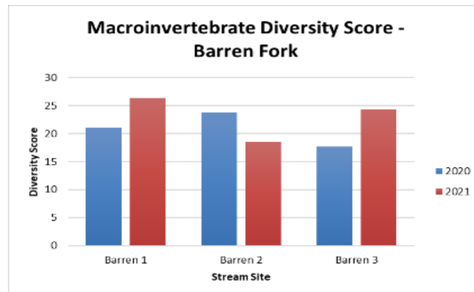


Figure 10: Change in macroinvertebrate diversity from 2020 to 2021.

Below are images showing sites on Barren Fork with high and low macroinvertebrate diversity. Barren 2 (left) is the site that sustains the highest level of macroinvertebrate diversity. While there are signs of active erosion as seen on the left stream bank, suitable habitat conditions for aquatic macroinvertebrates remain intact as suggested by the data above. Barren 3 (right) sustains the lowest level of macroinvertebrate diversity. There are no active indications of streambank erosion at this site, however, a strong presence of gravel substrate and gravel bars indicate active erosion upstream.

Figure 12: Visual comparison of sites with high (left) and low (right) macroinvertebrate diversity.

<u>Management Recommendations:</u>

1. Permanent or semi-permanent land conservation
2. Restoration of riparian forests, wetlands, and floodplains
3. Sustainable livestock practices such as rotational grazing and fencing cattle out of streams
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Caney Creek

Caney Creek is a largely rural watershed and is dominated by forested hillsides and agricultural pastures. The headwaters of the creek begin along Highway 59 close to Stilwell in Adair County, Oklahoma. The creek flows westward and eventually drains into Lake Tenkiller. There is no confluence between Caney Creek and either the Illinois River or the Barren Fork tributary.

2020 Impairments (Oklahoma DEQ)

Bacteria & Macroinvertebrate

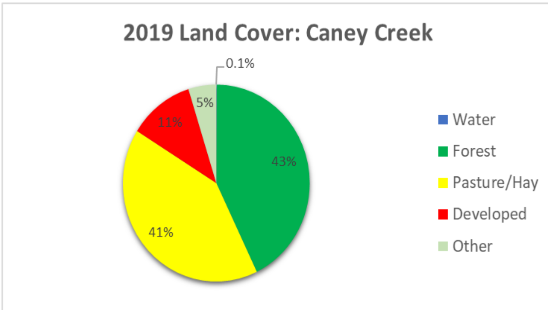


Figure 13: Land use in the Caney Creek subwatershed.

Table 3: Landuse change over time.

Caney Creek Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	44	43	40	-4
Forest	49	43	43	-6
Developed	6	10	11	5
Water	0.2	0.1	0.1	-0.1
Other	1	4	5	4

Data Summary

- The Caney Creek Subwatershed has undergone a 10% decrease in pasturelands and forested lands from 1992 through 2019. This area of land is home to high quality ecological communities as well as the westernmost portions of the Boston Mountain range. Continued loss of forested lands could have a significant impact on ecosystem health in this region. Deforestation has waned since 2016 and no change in forest land cover was observed through 2019 (Table 3).
- Caney Creek shows a relatively healthy community of macroinvertebrates with a diversity score of 25 (Figure 14).
- Caney 3 shows the highest diversity with a median score of 29.
- Caney 2 shows the lowest diversity score with an observed median of 19 (this site is frequently dry in the summer indicating subsurface flow of water and contributing to low population of macroinvertebrates) (Figure 15).
- Between 2020 and 2021, diversity scores remained the same or improved at Caney Creek sites (Figure 16).
- All site observations indicate a high level of suitable habitat for macroinvertebrates –

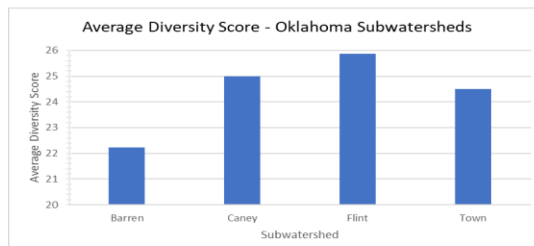


Figure 14: Average macroinvertebrate diversity in Oklahoma subwatersheds.

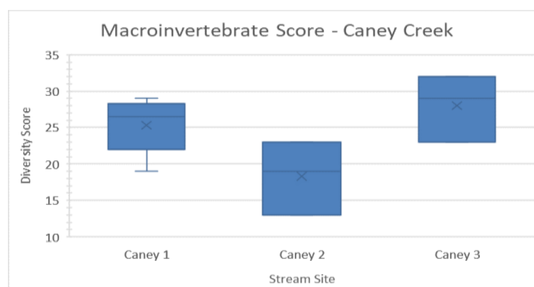


Figure 15: Average macroinvertebrate score across Caney Creek sites.

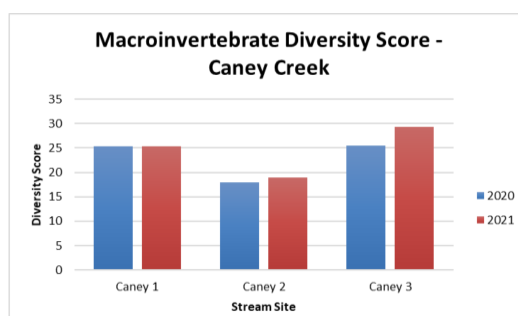


Figure 16: Change in macroinvertebrate diversity from 2020 to 2021.

cobbles and boulders – with very little observations of silt/clay/mud (Figure 17).

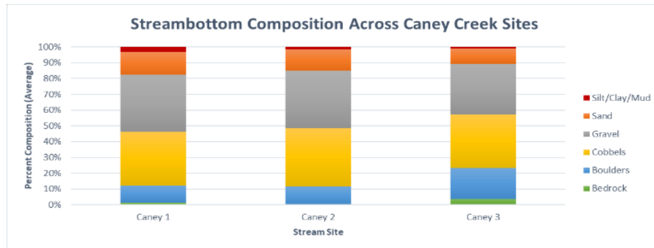


Figure 17: Streambottom composition in the Caney Creek subwatershed.

Below are images showing sites on Caney Creek with high and low macroinvertebrate diversity. Caney 3 (left) shows little to no signs of erosion with a healthy riparian buffer along the streambanks. Caney 3 received the second highest average diversity score (28.0) among the 12 Oklahoma sites sampled (Flint 4 received the highest average diversity score). Caney 2 (right) shows the lowest average diversity score (18 within the Oklahoma subwatersheds of this study). This is largely due to the steam udergoing intermittent flow during the summer months. The image below (right) shows the dry creekbed filled with mostly gravel. This would suggest elevated rates of erostion upstream of this site.

Figure 18: Visual comparison of sites with high (left) and low (right) macroinvertebrate diversity.

Management Recommendations:

1. Permanent or semi-permanent land conservation
2. Restoration of riparian forests, wetlands, and floodplains
3. Sustainable livestock practices such as rotational grazing and fencing cattle out of streams
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Flint Creek

The headwaters of Flint Creek are located in rural parts of Benton County, Arkansas. The creek flows into Oklahoma where it converges with Sager Creek and then into the main stem of the Illinois River. Flint Creek is a relatively small and unknown tributary, and it remains a high-quality, scenic stream system surrounded by forested lands.

2020 Impairments (Oklahoma DEQ)

Dissolved Oxygen & Phosphorus

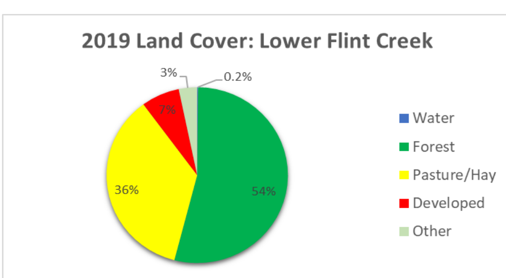


Figure 19: Land use in the Lower Flint Creek subwatershed

Table 4: Land use change over time.

Flint Creek Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	44	35	36	-8
Forest	53	57	54	1
Developed	0.5	6	7	6.5
Water	0.3	0	0.2	-0.1
Other	2	2	3	1

Data Summary

- After showing a 4% increase in forested land between 1992 and 2016, 3 percent of that gain was lost between 2016 and 2019. This may be explained by the 1 percent increase in developed land and 1 percent increase in pasture/hay land use (Table 4).
- Flint creek remained the most diverse subwatershed sampled for macroinvertebrates in both Arkansas and Oklahoma. Flint Creek data show an average macroinvertebrate diversity score of 25.9 (Figure 20).
- Flint 4 is the most diverse site across the subwatershed with an average score of 28, while Flint 3 was the least diverse site with a score of 23 (Figure 21).
- While Flint remains the most diverse site, diversity scores did decrease slightly from 2020 through 2021 (Figure 22).
- Flint Creek shows very little silt/clay/mud substrate across all sites observed (Figure 23).

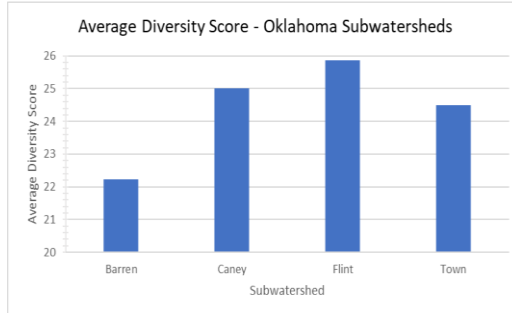


Figure 20: Average macroinvertebrate diversity in Oklahoma subwatersheds.

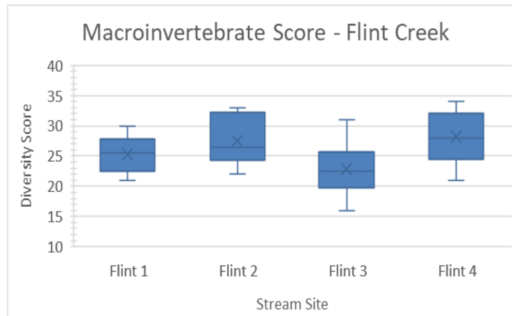


Figure 21: Average macroinvertebrate score across Flint Creek Sites

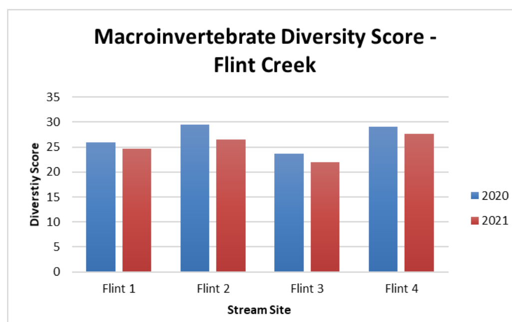


Figure 22: Change in macroinvertebrate diversity from 2020 to 2021.

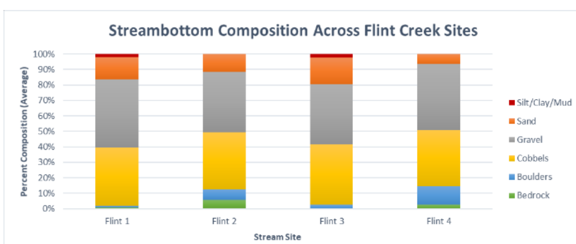


Figure 23: Streambottom composition in the Flint Creek

Both stream sites below show a healthy riparian buffer with little signs of erosion. This allows for habitat with little silt/clay/mud streambottom substrate. Additionally, we can infer that the rural land use upstream of these sites preserves streambottom composition, prevents erosion and silt/mud loading, and protects macroinvertebrate communities. Flint 4 (left) scored the highest diversity score and Flint 3 (right) the lowest for this subwatershed.

Figure 24: Visual comparison of sites with high (left) and low (right) macroinvertebrate diversity.

Management Recommendations:

1. Permanent or semi-permanent conservation of all forested parcels (upland and lowland) throughout the subwatershed.
2. Sustainable practices for livestock production such as rotational grazing and fencing cattle out of streams.
3. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Town Branch

Town Branch flows from north to south through the city of Tahlequah, Oklahoma where it connects with the Illinois River to the southeastern edge of the city. This stream has been impacted by the pressures of urbanization, however, the City of Tahlequah has taken steps to mitigate these challenges through several stream and riparian area restoration projects.

2020 Impairments (Oklahoma DEQ)

Bacteria (*E. coli*)

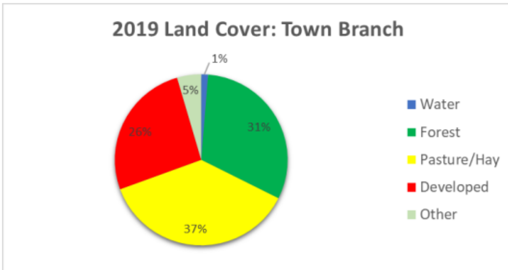


Figure 25: Land use in the Town Branch subwatershed.

Table 5: Land use change over time.

Town Branch Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	45	39	37	-8
Forest	36	32	31	-5
Developed	16	23	26	10
Water	1	1.1	1.3	0.3
Other	2.2	4.1	5	2.8

Data Summary

- Between 1992 and 2019, the Town Branch subwatershed lost 8% of pasture/hay landuse and 5% of forested land (Table 5)
- Developed land has increased by 10% since 1992 through 2019. (Table 5)
- Town Branch shows an average diversity score of 24.5 – exceptional for an urban stream system (Figure 26).
- Town Branch 1 scored a higher average diversity score of the two sections surveyed (27) (Figure 27)
- Town Branch 2 scored a lower average diversity score (23) (Figure 27).
- Town Branch shows a diverse streambed composition with a large portion of bedrock. This could indicate water moving at high velocities through the stream channel during peak flow events (Figure 29).
- Town Branch 1 shows a decrease of 4 points on its diversity score from 2020 to 2021 (Figure 28).
- Town Branch 2 shows an increase of 2 points on its diversity score from 2020 to 2021 (Figure 28).

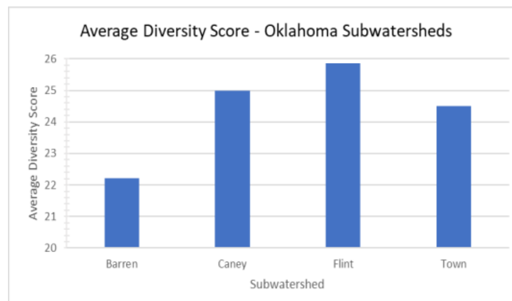


Figure 26: Average macroinvertebrate diversity in Oklahoma subwatersheds.

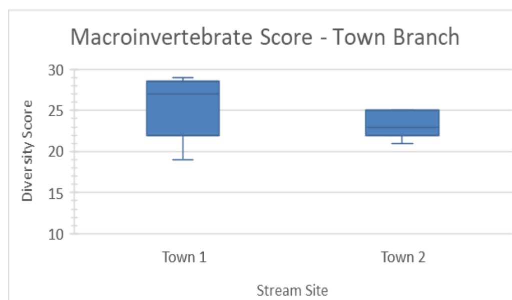


Figure 27: Average macroinvertebrate score across Town Branch Sites.

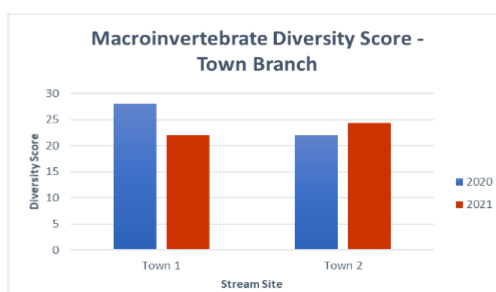


Figure 28: Change in macroinvertebrate diversity from 2020 to 2021.

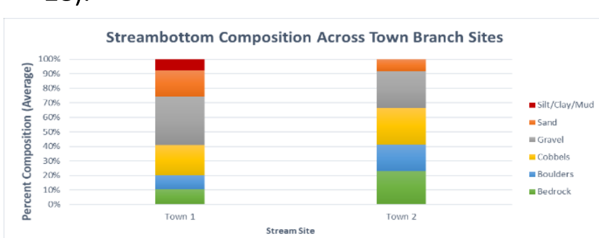


Figure 29: Streambottom composition in the Town Branch

Town 1 (left) scored the highest of the two sites observed. This image represents a typical stream reach within the city limits of Tahlequah – a mix of lawn, urban forest, and low density residential or commercial development. Contrary to conventional understanding of the pressures of urbanization on ecosystems, this site contained a healthier community (on average) of macroinvertebrates. Town Branch 2 (right) is a restored section of the stream. This site contains structured riffles, runs, and pools along with re-established riparian buffers. Although the long-term average diversity score for this site is lower, the data from 2021 shows a healthier macroinvertebrate community at this site for that year.

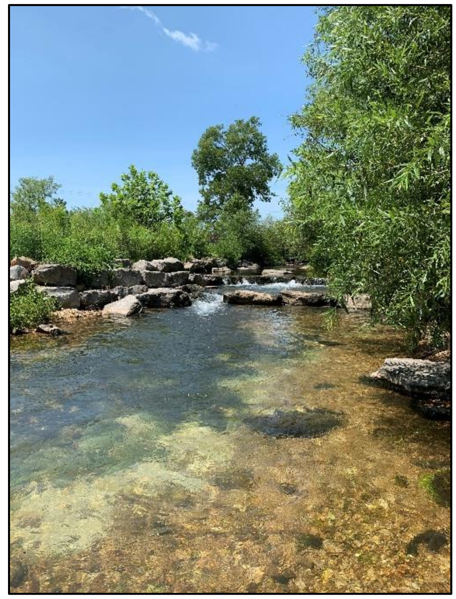


Figure 30: Visual comparison of sites with high (above) and low (right) macroinvertebrate diversity.

<u>Management Recommendations:</u>

1. Low impact development features on all parcels with impervious surfaces.
2. Permanent or semi-permanent land conservation on headwaters and upstream portions of the watershed.
3. Continued stream and riparian restoration projects.
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Arkansas

The Arkansas portion of the Illinois River Watershed lies predominantly in Benton and Washington Counties with a small portion crossing from Crawford County. Fishing, primary and secondary contact recreation, drinking water supply, and agricultural and industrial water supply are the designated uses for the Illinois River and its tributaries. However, portions of the Illinois River and tributaries have not been meeting these designated uses due to impairment from various sources – bacteria, sediment, nutrients (IRWP, 2012). Macroinvertebrate and streambottom data included in this report have been taken from the previous report as this year's data was collected in Oklahoma – 2022 will be focused on Arkansas. Landuse and impairment information, however, have been updated from the previous report and reflect the most up to date information.

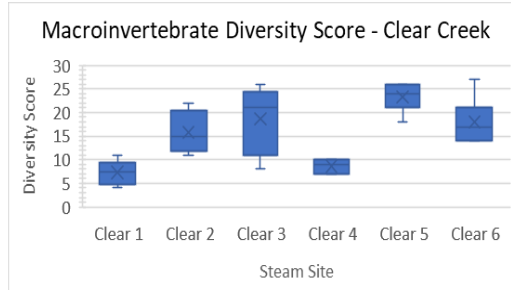


Figure 33: Average macroinvertebrate score across Clear Creek sites.

Four tributaries to the Illinois River were observed in 2018 & 2019 – Clear Creek, Moore's Creek, Muddy Fork, and Sager Creek. Continue reading below for our findings.

Clear Creek

Clear creek is the most urbanized subwatershed assessed in this project. The area continues to urbanize throughout the headwaters of all major tributaries. The assessed tributaries of Clear Creek include sites upstream and downstream of Lake Fayetteville – a reservoir created in 1949 as a drinking water supply for the City of Fayetteville. Today, the lake features extensive recreational amenities that are owned and managed by the city.

2020 DRAFT Impairments (Arkansas DEQ)

Not Listed

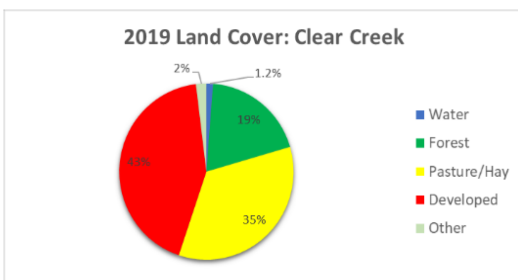


Figure 31: Land use in the Town Branch subwatershed.

Table 6: Land use change over time.

Clear Creek Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	58	37	35	-23
Forest	18	21	19	1
Developed	17	39	43	26
Water	3	1	1.2	-1.8
Other	5	1	2	-3

Data Summary

- Urban development in the Clear Creek subwatershed has increased by 26% from 1992 to 2019 (up 3% from 2016). Areas upstream of Lake Fayetteville are particularly vulnerable as farmland and remnant prairies are converted to medium to low density urban development (Table 6).
- Clear Creek received a diversity score of 16 – the second highest in Arkansas (Figure 32).
- Stream sites 1 and 4 show two of the least diverse sites across the entire scope of this

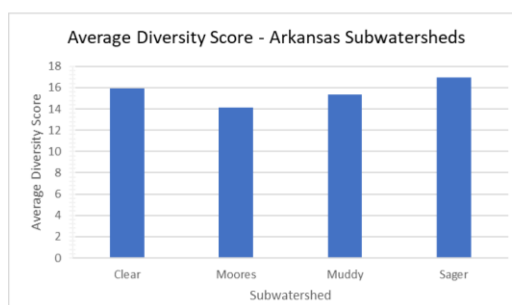


Figure 32: Average macroinvertebrate diversity in Arkansas subwatersheds.

study but also one of the highest in Arkansas (Clear 5) (Figure 33).

- Clear Creek shows a slight decrease in macroinvertebrate diversity from 2018 to 2019 (2018 = 17, 2019 = 15) (Figure 34).
- The stream bottom composition for Clear Creek found silt/clay/mud are the lowest observations for Arkansas. The composition of Clear Creek 5 appears to be the most suitable for macroinvertebrate diversity – high cobble/gravel with low bedrock and silt/clay/mud (Figure 35).

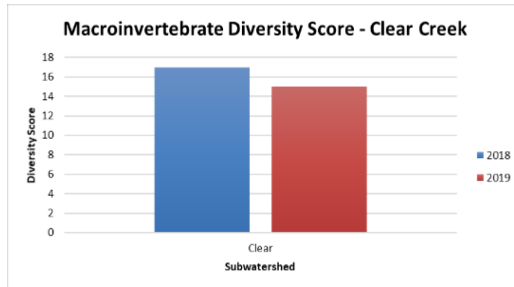


Figure 34: Change in macroinvertebrate diversity from 2018 to 2019.

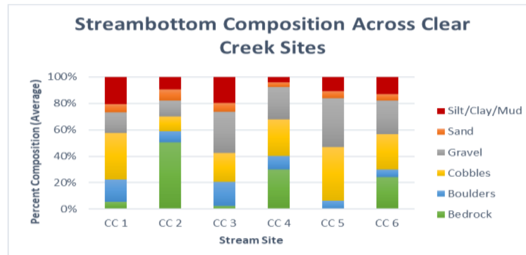


Figure 35: Streambottom composition in the Clear Creek

The Clear Creek site at the left recorded higher diversity and presence of gravel and cobbles than the site at the right, but both indicate "incision". Incision is a common occurrence in urban creeks and streams and occurs when a creek or stream loses access to a wetland or floodplain. This leads to larger quantities and velocities of water, resulting in a "snow-ball affect" of erosion not only laterally along the streambank but also to lower elevations below the original streambed.

Figure 36: Visual comparison of Clear Creek sites.

Management Recommendations

1. Permanent or semi-permanent conservation of undeveloped areas around waterways.
2. Low Impact Development practices for all parcels with residential or commercial development.
3. Restoration of all incised stream reaches using natural channel design, followed by permanent conservation of surrounding land.

4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Moore's Creek

Moore's Creek is a rural subwatershed located in southern Washington County, Arkansas. The city of Lincoln (pop. 2,444) is located in the watershed and includes Lincoln Lake – a 90-acre reservoir originally used as the city's water supply. The lake offers recreation opportunities including mountain biking, hiking, rock climbing, non-motorized boating, and fishing. Agricultural land is the predominant land use, but large areas of forest exist at upper elevations on the norther boundary of the Boston Mountains.

<u>*2020 DRAFT Impairments (Arkansas DEQ)*</u>

Bacteria (*E. coli*) &

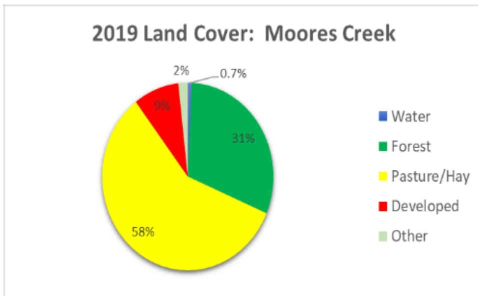


Figure 37: Land use in the Moore's Creek subwatershed.

Table 7: Land use change over time.

Moores Creek Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	59	61	58	-1
Forest	31	30	31	0
Developed	2	7	9	7
Water	1	0.7	7	6
Other	6	2	2	-4

Data Summary

- Developed land has increased by 7% between 1992 and 2019. This increase is likely due to the conversion of land designated by our model as "other". Land uses in this category include row crops, grass/shrub land, and barren land (Table 7).
- Moore's Creek has the lowest average macroinvertebrate diversity recorded in this study (14) (Figure 39).
- Moore's 2 has the lowest average diversity within this subwatershed with a high percentage of silt/clay/mud and bedrock substrate on the streambottom – unsuitable habitat for macroinvertebrates (Figure 38).
- Moore's 4 has the highest average diversity (17) which can be described as unexpected when analyzing the streambottom composition at this site. Although a high percentage of silt/clay/mud is present at this site, the habitat is suitable to remain slightly above average for Arkansas (Figure 41).
- Average diversity decreased slightly from 2018 (15) to 2019 (14) (Figure 42).

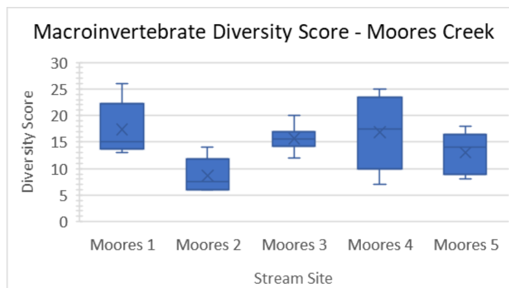


Figure 38: Average macroinvertebrate score across Moore's Creek sites.

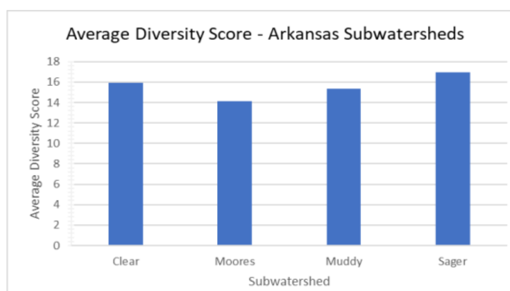


Figure 39: Average macroinvertebrate diversity in Arkansas subwatersheds.

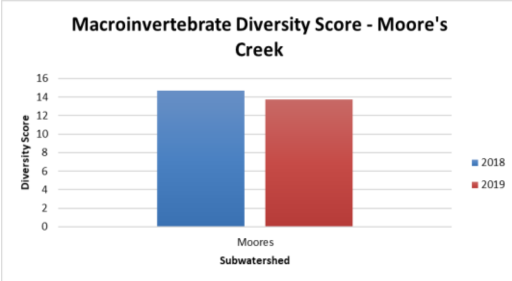


Figure 41: Change in macroinvertebrate diversity from 2018 to 2019.

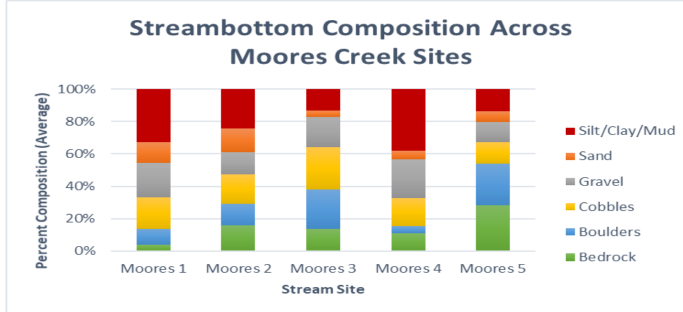


Figure 40: Stream bottom composition in the Moore's Creek subwatershed.

The site of the left, located upstream of Lincoln Lake, is a good example of the diversity of stream habitat that is needed to support diverse macroinvertebrate communities. The creek is on the same elevation as the surrounding land use, indicating no incision or erosion is occurring. And there is a wide variety of rock sizes, surface types, and flow regimes that macroinvertebrates can utilize. The site on the right, on the other hand, is incised and eroding, contains turbid water (indicating deposition of silt and mud), and lacks variation in habitat (i.e. no riffles, runs, or pools).

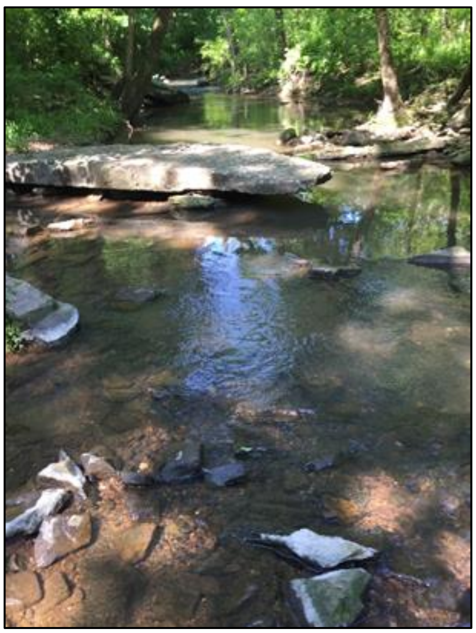


Figure 42: Visual Comparison of Sites with High Numbers of Gravel and Cobbles Observations

Management Recommendations

1. Re-establish riparian forests, wetlands, and floodplains
2. Permanent or semi-permanent conservation of areas around headwaters and/or forested hillsides.
3. Sustainable livestock practices such as rotational grazing and fencing cattle out of streams.
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Muddy Fork

2020 DRAFT Impairments (Arkansas DEQ)

Bacteria (*E. coli*)

Muddy Fork subwatershed is located just east of the Moore's Creek subwatershed. The headwaters are located just south of the city of Prairie Grove and the stream flows north until it converges with the Illinois River mainstem at Savoy. Land use is similar to Moore's Creek with pasture lands dominating flat, low-lying areas and forested hillsides towards the south end of the watershed.

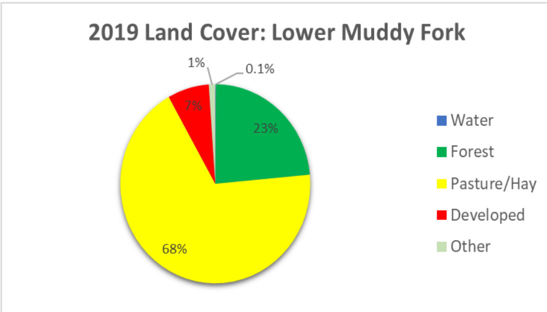


Figure 43: Land use in the Muddy Fork subwatershed.

Table 8: Land use change over time.

Muddy Fork Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	69	70	68	-1
Forest	22	23	23	1
Developed	1	6	7	6
Water	1	0.1	0.1	-0.9
Other	8	1	1.1	-6.9

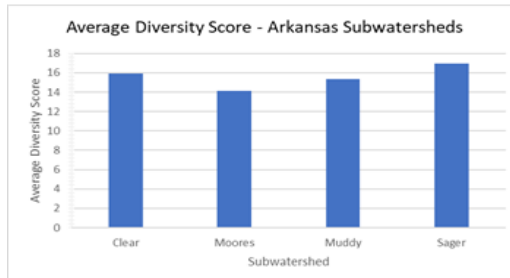


Figure 44: Average macroinvertebrate diversity in Arkansas subwatersheds.

Data Summary

- Muddy Fork has undergone a 6% increase in development. This is likely due to the conversion of the land categorized as "other" (row crops, grass/shrub land, and barren land) (Table 8).
- Muddy Fork scored slightly below average for macroinvertebrate diversity (15) (Figure 44).
- While most sites observed in Muddy Fork (1, 2, & 3) maintained a median above average, one site is significantly lower (Muddy 5 = 5) (Figure 45). In comparison, Muddy 4 has a median of 12.5, however, the steambottom at this sight contains higher amounts of silt/mud/clay and lower number of cobbles (Figure 47). This would suggest less suitable habitat for macroinvertebrates, however, our data suggests otherwise. Additional water quality monitoring is recommended at this site.
- Muddy Fork has the second highest percent observations of silt/clay/mud – Moore's Creek contains the highest (Figure 47).
- Overall, Muddy Fork increased in diversity between 2018 and 2019 (14 to 16) (Figure 46).

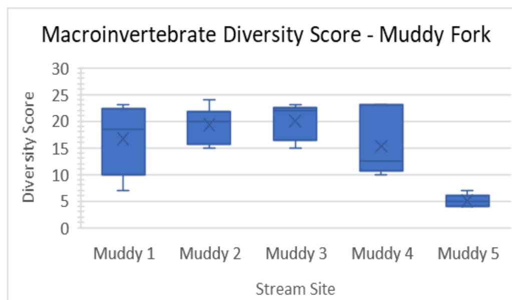


Figure 45: Average macroinvertebrate score across Muddy Fork sites.

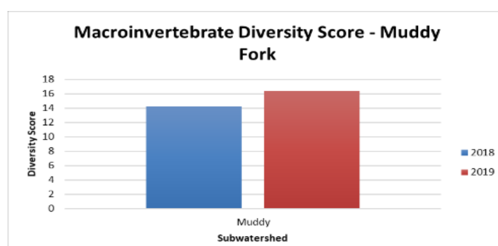


Figure 46: Change in macroinvertebrate diversity from 2018 to 2019.

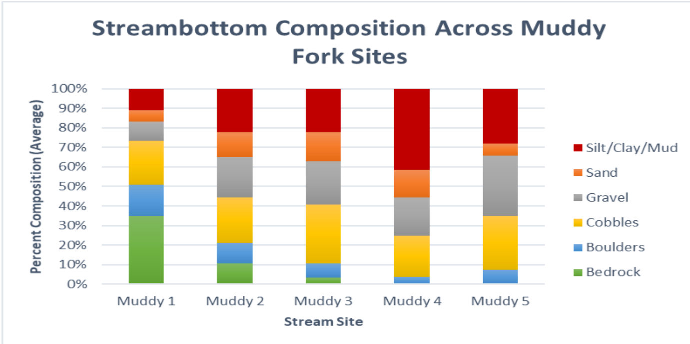


Figure 47: Streambottom composition in the Moore's Creek subwatershed.

The left-hand site is a small creek runs through pasture lands with little riparian forest. The streambank is somewhat incised and the reach may have been trenched at some time in the past. The right-hand site is a good example of stable streambanks with little incision. On the other hand, the stream is deep throughout with few riffles, which indicates degradation of the stream bottom composition that is necessary for diverse communities.

Figure 48: Visual Comparison of Sites with High Numbers of Gravel and Cobbles Observations

Management Recommendations

1. Re-establish riparian forests, wetlands, and floodplains.
2. Permanent or semi-permanent conservation of areas around headwaters and/or forested hillsides.
3. Sustainable livestock practices such as rotational grazing and fencing cattle out of streams.
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Sager Creek

> *2020 DRAFT Impairments (Arkansas DEQ)*
>
> Nitrate (relisted)

Sager Creek is technically a tributary of the Flint Creek subwatershed and is located in the Siloam Springs area of Arkansas. The historic ecology of the area has been upland prairie and oak savannah which has since been converted into pasture lands. Siloam Springs has also experienced rapid urban growth recently and has taken steps to conserve and protect Sager Creek during this period of growth. The City of Siloam Springs owns much of the land surrounding Sager Creek and has annexed the land for paved trail use as well as an extensive riparian reforestation effort during the early 2000's.

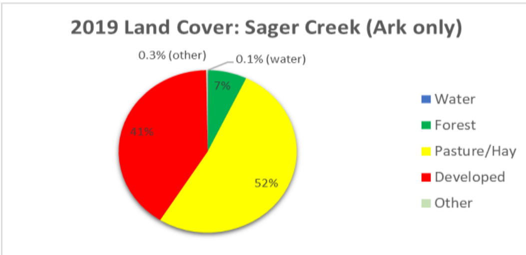


Figure 49: Land use in the Muddy Fork subwatershed.

Table 9: Land use change over time.

Sager Creek Land Use Comparison				
	1992 (%)	2016(%)	2019 (%)	% Change (1992 - 2019)
Pasture/Hay	68	55	52	-16
Forest	8	7	7	-1
Developed	18	38	42	24
Water	0.5	0	0.1	-0.4
Other	6	0	2	-4

Data Summary

- Developed land increased by 24% from 1992 to 2019. This is likely due to the conversion of pasture/hay land. Development in this area is expected to continue to rise along with the growth of Northwest Arkansas (Table 9).
- Sager Creek has the most diversity among the Arkansas watersheds included of this study (17) (Figure 50).
- Sager 1 has the least diversity (Figure 51) which is what would be expected when observing the streambottom composition at this site. Silt/clay/mud dominated the substrate at this site (Figure 53). This site also has a mix of stream, wetland, and stormwater retention features.
- Sager Creek also has the highest percentage of cobbles across all Arkansas watersheds.
- Diversity in Sager Creek maintained relatively stable from 2018 to 2019 (Figure 52).

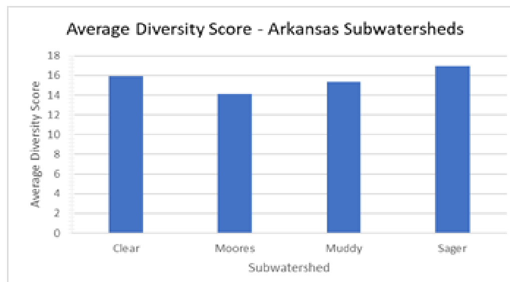


Figure 50: Average macroinvertebrate diversity in Arkansas subwatersheds.

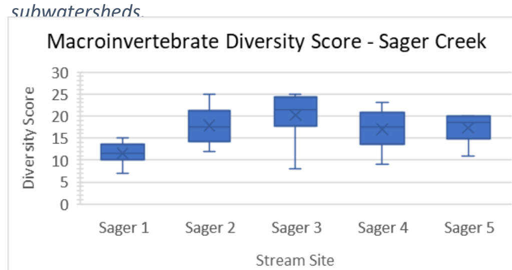


Figure 51: Average macroinvertebrate score across Sager Creek sites.

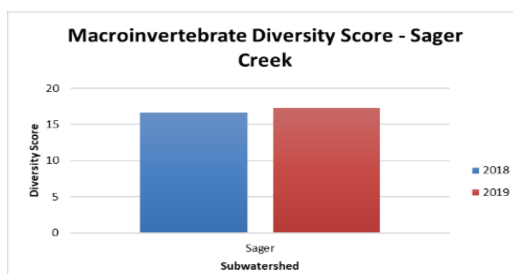


Figure 52: Change in macroinvertebrate diversity from 2018 to 2019.

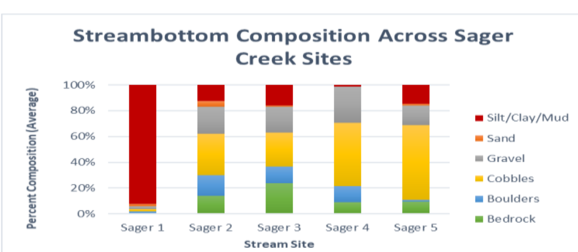


Figure 53: Streambottom composition in the Moore's Creek

The site in the left-hand photo demonstrates healthy riparian vegetation that has been re-established in the last 15 years by the City of Siloam Springs. There is no active erosion and little silt, clay, or mud in the streambed. While not aesthetically pleasing, the photo at right is a site that is a mix of wetland, stream, and stormwater detention feature that is located upstream of the left-hand photo site. The presence of silt, clay, and mud at this site was very high, but not unexpected given its function.


Figure 54: Visual Comparison of Sites with High Numbers of Gravel and Cobbles Observations

Management Recommendations

1. Low impact development features on all parcels with impervious surfaces.
2. Permanent or semi-permanent land conservation on headwaters and upstream portions of the watershed.
3. Continued stream and riparian restoration projects.
4. Continued water quality monitoring including parameters such as dissolved oxygen, pH, and nutrients.

Conclusion

As discussed in the introduction, our objective in performing this assessment is to provide decision makers within each subwatershed with information to make informed decisions regarding land use, urban planning, stormwater mitigation, and natural resource conservation opportunities. The Illinois River is of historic, cultural, recreational, and economic importance to Northwest Arkansas and Eastern Oklahoma and it our hope that stakeholders, landowners, and the general public will recognize it as such.

For this four-year study, macroinvertebrate diversity was most related to components of the streambed and not necessarily related to components of the streambank or surrounding land use. Diversity was positively related to the presence of cobbles and gravel in the streambed and negatively related to the presence of silt, clay, and mud in the streambed. Assuming the presence of cobbles and gravel is the "natural" state (i.e. would be present at all sites if it were not for the presence of silt, clay, and mud), management recommendations include practices that have been shown to reduce the presence of these small, light, and highly erodible soil particles that are introduced to the stream via either over-land flow during rain events or streambank erosion. Other studies conducted by IRWP indicate that streambank erosion from both urban and rural settings is one of the largest contributors of phosphorus to the watershed.

Land use has not changed significantly across the entire watershed but is changing significantly in one area of the watershed. The population of Northwest Arkansas is expected to almost double over the next 20 years and most of the resulting land use change will occur in the Illinois River Watershed. It will likely occur in the form of pasture lands and farms converting to low density residential and commercial developments. Conserving and restoring high-value natural resources needs to happen now as prevention is (generally) much less expensive than remediation. Interestingly, two urban subwatersheds, Sager Creek and Town Branch, that recently embarked on urban stream restoration projects had relatively high macroinvertebrate diversity, indicating that such projects can prevent erosion and deposition of sediment, as well as restore ecological function.

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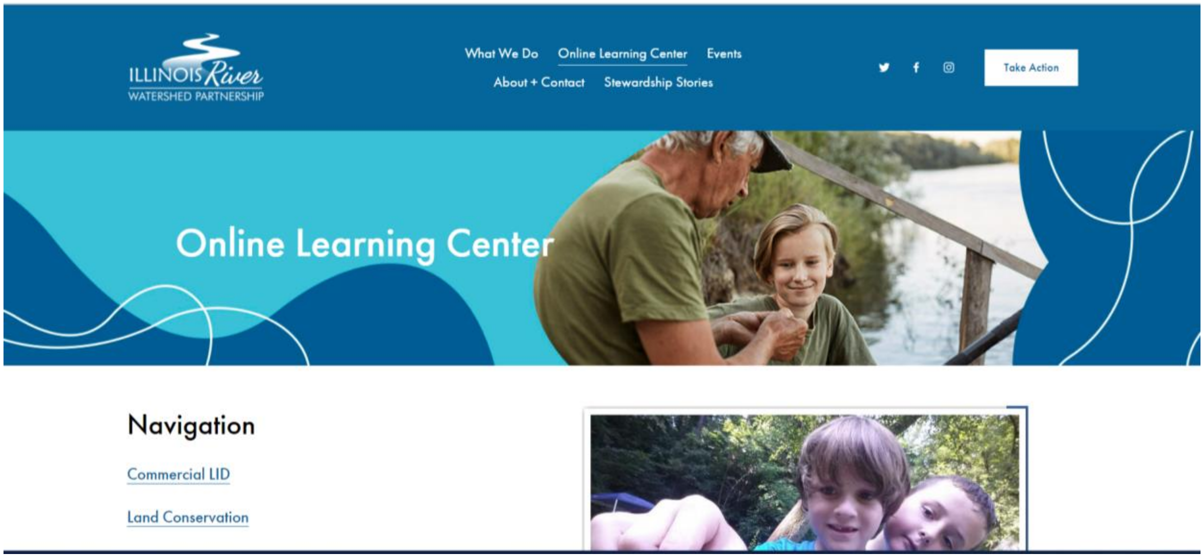
To learn more about the management practices recommended here, visit our Online Learning Center at

www.IRWP.org/OnlineLearningCenter




ILLINOIS River
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