Impacts of Cattle Farming on Local Freshwater Streams

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Introduction

Missouri's rich soil and expansive, relatively flat, landscape make it perfect for farming. Approximately two-thirds of the state is used for agricultural lands, with a total of nearly 100,000 farms operating in the state ("Missouri Ag Highlights", n.d.). Of Missouri's 100,000 farms, fifty-three percent of owners reported having cattle in 2012 ("Missouri Beef Resource Guide", n.d.). According to the USDA- National Agricultural Statistics Services (NASS), in 2017, the total number of cattle, including calves, in Missouri was 4,450,000 heads ("2017 State Agriculture Overview", n.d.), with the majority of cattle-farms having fewer than fifty heads of cattle ("Missouri Beef Resources Guide", n.d.).

The prevalence of cattle farming in Missouri makes it worthwhile to study the impact of the industry on the surrounding environment. It can be difficult for farmers to control cattle byproduct runoff, including, "the feces, urine, ration waste, and wastewater of cleaning the cattle and the pens," into nearby streams, which may adversely impact stream quality (Widiastuti, et al. 2015). Increased nutrient levels in streams near farms is common, including directly after field fertilization, and in the winter, when there is little vegetation to collect farm discharge and runoff (Renwick, et al., 2008). The large number of cattle farms in Missouri helped with forming our hypothesis for assessing if an impact on stream health is present.

There are more than 110,000 miles of running water in Missouri ("Rivers and Streams", n.d.). The James River Watershed includes approximately 363 miles of streams covering the
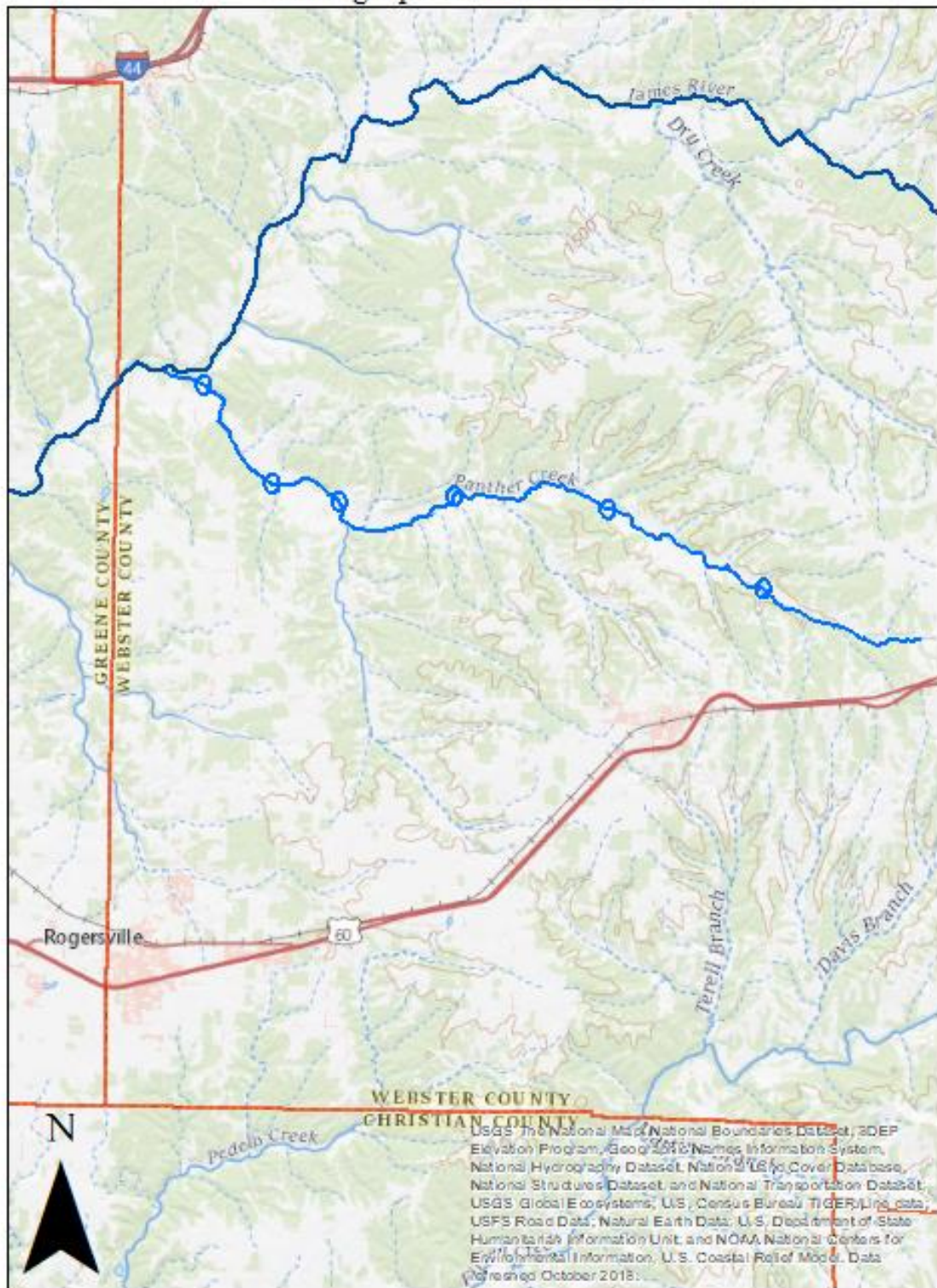
counties of Webster, Greene, Christian, Stone, and Barry in southwest Missouri, and the watershed covers 1,512 square miles of land (Kiner & Vitello, 2016). Sixty-three percent of the land is used for agricultural purposes.

The agricultural areas around Springfield, MO are heavily used for cattle farming. Though there is currently literature addressing the general impacts of cattle farming on stream quality, this study would focus on the impacts on local streams northeast of the Springfield, MO area. We will focus on three cattle farms along the Webster County portion of Panther Creek, before it widens into the James River in Greene County. Panther Creek is part of the Panther Creek Watershed, which is located at one of the northernmost regions of the James watershed ("Missouri Watersheds", n.d.). Panther Creek is a fourth order stream and is 11.89 miles long (Kiner & Vitello, 2016). Panther Creek is a Class P stream, so it maintains permanent flow even during drought periods (Kiner & Vitello, 2016). There are no permitted point sources directly to Panther Creek, although it is noted that there may be potential nonpoint sources that influence the creek, including farming operations (Kiner &Vitello).

Since this waterway is smaller in width and depth, it can be assumed that pollutants will not dilute as much and have a greater impact on the quality of the water. We expect to see higher turbidity and E. coli. levels, lower dissolved oxygen level and benthic macroinvertebrate biodiversity, and levels of pH, temperature, flow rate that decrease the quality of water for living organisms. We expect that an increased number of cattle farming around Panther Creek will have a negative correlation with the health of Panther Creek. If cattle farming has a statistically significant negative impact on stream quality, then there will be implications for local conservation and management.

Panther Creek: Testing Sites

Cartographer: Olivia Biles

44

James River

Dry Creek

1500

Panther Creek

GREENE COUNTY
WEBSTER COUNTY

Terell Branch

Davis Branch

Rogersville

60

WEBSTER COUNTY
CHRISTIAN COUNTY

Pedelo Creek

USGS The National Map National Boundaries Dataset, 3DEP
Elevation Program, Geographic Names Information System,
National Hydrography Dataset, National Land Cover Database,
National Structures Dataset, and National Transportation Dataset;
USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data;
USFS Road Data; Natural Earth Data; U.S. Department of State
Humanitarian Information Unit; and NOAA National Centers for
Environmental Information, U.S. Coastal Relief Model. Data
refreshed October 2018.

N

4,500

Meters

Legend

JamesRiver

PantherCreek

Methods

Both abiotic and biotic variables will be tested. Abiotic variables will include turbidity, pH, flowrate, temperature, and dissolved oxygen level. Biotic factors include e. coli level and benthic macroinvertebrate biodiversity

Testing sites will be along sideroads where there is creek access, primarily near bridges. The abiotic and biotic variables above will be measured at each site, both upstream and downstream of the cattle farm. This will control for other nonpoint source pollutants from outside sources, other than cattle farms, impacting stream quality. This ensures that our results are not impacted by outside variables and focus solely on the hypothesis, the impact of cattle farming on stream quality.

We will be using a variety of different methods to test our variables. All abiotic variables will be tested on site, while the biotic variables will be tested in the lab. We will compute benthic macroinvertebrate biodiversity by the Shannon-Wiener Index once during the study at all six subsites. For abiotic factors, all six subsites will be visited eight times, twice a week until completion of the study. Simple t-tests will be run to compare each farm's upstream site data to the downstream site data. These results will show us if there is a significant difference in upstream versus downstream readings. This will allow for a conclusion to be made determining if the accessed stream's health is negatively impacted by the cattle farms.

Each site has two subsites: one upstream of the corresponding cattle farm and one downstream. This will control for outside variables possibly skewing results so the focus can be on the specific impacts of cattle farming

Measuring oxygen levels is important because it helps, "determine whether and what types of organisms can live in a given ecosystem" (Dodds, 2002). Both oversaturation and undersaturation of dissolved oxygen levels in water can inhibit photosynthesis, decreasing productivity across the entire ecosystem. We will be measuring dissolved oxygen levels in both milligrams per liter and percentage saturation using a dissolved oxygen meter (AQUAREAD, 2019). Water temperature is also an indicator of whether organisms can live in the stream and which organisms inhabit it. Fluctuation in temperature greatly impacts what organisms can survive in the water.

Measuring turbidity will be a simple, yet powerful way to see impacts of cattle farming and subsequent discharge on stream quality. Excess debris and pollutants are, "able to change the ecosystem structure and decrease the number of the species in a community, causing the varieties to decrease as well (Widiastuti, et al. 2015)." Excess debris and pollutants are often visible and can be measured by turbidity. Turbidity will be measured with a turbidity tube.

Measuring flowrate is important because it can be an indicator of debris levels and outside interference with the aquatic ecosystem. Flowrates will be measured using a flow meter. The time it takes a floating object, such as a ping pong ball, to travel 20 meters can also be used in the place of electronic equipment. This process is kept consistent by staking both start and end points, then running three trials. Measurements will be taken from areas of primary velocity at each site, avoiding regions where the pace of the water inconsistent.

We will be measuring stream pH levels to see if cow manure will have a significant impact on pH in aquatic environments. pH levels will be measured using a pH meter. Measuring pH levels is important because species have optimal pH levels where productivity is greatest, with that optimal level being found close to near neutrality (Dodds, 2002). Even slight changes

in pH range can potentially lead to drastic changes in species productivity and health (Irwin, 2002). Cow manure is usually around a neutral pH and can bring soils with extreme pH levels close to neutral over time, which impacts vegetation.

Samples of benthic macroinvertebrate biodiversity will be utilized to determine if cattle farming has an impact. Randomized kick-sampling will be used to collect samples. We will use *A Guide to Common Freshwater Invertebrates of North America* by J. Reese Voshell, Jr and Save Our Streams program resources to identify all benthic macroinvertebrates found in the lab.

Cattle farms are prime environments for the spread of STEC 0157, the most studied strand of e. coli (Edrington, 2012). It is easy for e. coli from cattle farms to arrive in adjacent streams and disrupt their ecosystems. This can happen through direct contact between cattle and streams, or soil erosion and runoff. We will be measuring e. coli levels using a Quanti-Tray IDEXX system. Diversity will be computed using the Shannon-Wiener Index. The number of families found in the sample will tell us the taxa richness.

Results

Turbidity (m)	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Visit 7	Visit 8	**Average**
P1U	0	2.1	4.9	1	0.6	0	0	0	**1.08**
P1D	0	1.7	1	0.3	0.2			0	**0.53**
P2U	0	1.2	0.6	0	0.4	0	0	0	**0.28**
P2D	0	1.4	1.3	0.4	0.1	0	0	0	**0.4**
P3U	0	2.8	0.5	0.5	1.5	0	0	2.7	**1.00**
P3D	0	2	1.6	0.4	0.9	0	0	0	**0.61**

pH

P1U	8.3	7.21	7.73	8.32	8.15	7.11	7.33	6.76	**7.61**
P1D	8.4	7.06	7.54	7.25	8.42			7.22	**7.65**
P2U	8.5	7.44	7.78	8.48	8.27	7.25	7.55	6.72	**7.75**
P2D	8.3	7.33	7.73	8.36	8.12	7.09	7.22	6.56	**7.59**
P3U	8.4	7.73	6.95	6.62	7.57	6.83	6.7	6.5	**7.16**
P3D	8.2	6.6	7.26	7.64	7.96	7.01	7.09	6.61	**7.30**

Temp. (Celsius)

P1U	14	13.21	17.43	15.28	16.86	13.17	17.11	15.71	**15.35**
P1D	13.8	12.82	17.53	15.4	17.21			17.95	**15.79**
P2U	13	12.58	17.41	15.35	16.85	12.54	17.23	15.41	**15.05**
P2D	14	12.98	17.04	15.16	16.51	13.1	16.8	15.48	**15.13**
P3U	12.5	12.34	15.82	14.75	15.9	10.97	16	14.67	**14.12**
P3D	12.75	12.34	16.17	14.75	15.96	11.94	15.99	14.77	**14.33**

Flowrate (m/s)

P1U	1.1	1.1	1.1	0.9	1.1	1.3	1	2.4	**1.25**
P1D	1	0.9	0.9	1.1	1.1			1.7	**1.12**
P2U	1.3	1.3	0.9	1.3	1.3	1.3	0.5	2.4	**1.29**
P2D	0.9	1.3	0.9	0.9	1.1	1.1	1	1.7	**1.11**
P3U	0.7	1.3	1.1	1.3	1.1	1.3	0.9	3.1	**1.35**
P3D	2.2	0.7	0.7	0.5	0.5	0.7	0.5	1.4	**0.9**

Dissolved Oxygen (mg/L)

Site	V1	V2	V3	V4	V5	V6	V7	Avg
P1U	14.65	15.35	15.03	15.5	11.93	12.49	11.56	**13.79**
P1D	13.7	14	21.32	14.97			12.44	**15.29**
P2U	15	14.44	14.93	15.21	12.11	12.18	12.07	**13.71**
P2D	14.75	14.89	15.01	14.9	11.59	11.48	11.26	**13.41**
P3U	16.37	13.55	11.92	12.54	10.35	9.46	10.51	**12.1**
P3D	14.68	14.3	13.74	14.27	11.05	11.56	10.88	**12.93**

E. coli present

Site	V1	V2	V3	V4	V5	V6	V7	V8	Avg
P1U	10.7	64.4	28.8	34.1	33.9	70.3	185	1011.2	**179.8**
P1D	4.1	17.5	4.1	11	8.5	30.9	18.5	1011.2	**138.23**
P2U	8.5	16.9	8.4	18.3	15.8	35.5	12	137.4	**31.6**
P2D	14.6	32.3	4.1	4.1	27.9	27.2		689.3	**114.21**
P3U	8.5	52.9	23.1	23.1	93.4	156.5	24.3	829.7	**151.44**
P3D	44.1	53.8	501.2	33.9	50.4	65.7	70.3	151	**121.3**

We collected the data above over the course of eight trips to the testing sites. Dissolved oxygen (DO) was not measured on our first site visit because we were not yet in possession of the multimeter. For site P1D on visits 6 and 7, all data except for E. coli presence was lost. After Visit 7 for site P2D, the sample of water was dropped in the lab, so no values for E. coli are given that day. Visit 8 was the only round of measurements taken the day after a mild rain moved through the area, so the low pH, high flowrate, and high E. coli counts stand out for that visit.

Sites P3U and P3D were compared and showed no significant differences in value (p-values: E. coli=0.795, turbidity=0.460, pH=0.679, temperature=0.819, flowrate=0.226, DO=0.467). Sites P2U and P2D also showed no significant difference in values (p-values: E. coli=0.428, turbidity=0.644, pH=0.625, temperature=0.927, flowrate=0.430, DO=0.744). We compared sites P2D and P1U as up and down sites, respectively, because upon arriving to site P1U we realized the cattle at Farm 1 had direct access to the stream above our testing site when they were moved to that certain pasture. Therefore, site P2D as an up site compared to site P1U as a down site showed no significant difference in values (p-values: E. coli=0.677, turbidity=0.426, pH=0.937, temperature=0.804, flowrate=0.495, DO=0.696). Site P1U and P1D, as well, did not show significant difference in values (E. Coli=0.814, turbidity=0.555, pH=0.918, temperature=0.689, flowrate=0.536, DO=0.416).

Benthic Macroinvertebrate Biodiversity Raw Data							
	P3U	**P3D**	**P2U**	**P2D**	**P1U**	**P1D**	**Total**
Worms	4	9	5	2	5	0	25
Crayfishes	0	1	0	0	0	0	1
Sowbugs	8	7	31	0	1	0	47
Stoneflies	228	135	113	37	150	23	686
Mayflies	30	143	575	115	260	201	1324
Hellgrammites Fishflies, and Alderflies	0	1	1	0	2	0	4
Common Netspinners	0	5	0	0	2	0	7
Most Caddisflies	15	61	138	30	272	45	561
Beetles	121	186	4	2	15	10	338
Midges	0	0	0	0	2	0	2
Black Flies	342	0	0	0	0	0	342
Most True Flies	9	21	16	46	6	11	109
Lunged Snails	0	0	2	0	1	0	3
Gilled Snails	0	0	0	0	30	0	30
Total	757	569	885	232	744	290	3479

Shannon Index Numbers	
P3U	1.35
P3D	1.6
P2U	1.1
P2D	1.31
P1U	1.4
P1D	0.98

Our benthic macroinvertebrate samples were taken the same day as Visit 7 measurements were taken. We took between four and five zip-lock bags of preserved specimens back to our laboratory site, but due to time constraints, only opened and separated one bag for each site, so sites P2D and P1D show fewer than 500 individual macroinvertebrates accounted for. With more time, we would have counted another whole bag of preserved bugs for both of these sites. The most common macroinvertebrate found were mayflies, which are moderately tolerant when it comes to water quality (Teller, 2014), showing an overall fair health for the stream. The caddisfly larvae and gilled snails are apparently two of five of the most intolerant categories to water pollutions (Teller, 2014), and site P1U had the most of each of these macroinvertebrates.

We used the Shannon-Weiner Diversity Index to identify which sites had the highest biodiversity. The higher Index number shows a higher biodiversity. We will compare sites as we did with the other measured criteria prior. Site P3D has a higher biodiversity index than site P3U. Site P2D similarly has a higher biodiversity index than site P2U. Site P1U (acting as the down-site in this case) has a higher biodiversity index than site P2D (acting as up-site); it also has a higher index (acting as up-site) than site P1D. The site with the highest biodiversity index was P3D (=1.6) and the lowest was P1D (=0.98)

Discussion

We expected to see that sites upstream from farms would have significantly better water quality when compared to sites downstream from farms, especially if those farms allowed cattle direct access to the stream. No site comparisons showed significant difference between our measured qualities. Because of this, we cannot conclude with certainty that cattle farms located along Panther Creek are negatively affecting the stream quality. Although we did not confirm it with the homeowners, we speculated that at site P3U, one of the homes may have a leaking septic tank or something of that nature because on several occasions, the site had uncommonly low pH levels or low DO levels. Perhaps if the tests were continued to be taken through the rest of the year, we would have a better idea of what this stream looks like through warmer and colder times of the year.

With further exploration of this research, we hope to correspond with local conservation departments and management. By discussing with locals in the field, methods can be addressed to best regulate the health of local streams. We also hope to discuss our results with local cattle farmers. Conversations could be made with cattle raisers about alternative techniques to prevent cattle from adversely impacting the quality of local streams. The Panther Creek watershed flows into the James River watershed. This watershed flows into Table Rock Lake, a lake of large economic and cultural value in the community, whether that be the tourist industry or outdoor recreation industry. Protecting stream health trickles down to positively affect the entire water system.

Works Cited

"2017 STATE AGRICULTURE OVERVIEW." *USDA - National Agricultural Statistics Service*

    Homepage, 2017,

    www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=MISSOURI.

"Missouri Ag Highlights." *Missouri Department of Agriculture*,

    agriculture.mo.gov/topcommodities.php.

"Missouri Beef Resource Guide." *Missouri Beef Farms - Missouri Beef Resource Guide*,

    beef.missouri.edu/industry/beeffarms.htm.

"Missouri Watersheds." *ArcGIS Web Application*, U.S. Geological Survey (USGS) Water

    Resources Division (WRD) and U.S. Department of Agricultural (USDA) Natural

    Resources Conservation Service (NRCS) Watershed Boundaries Dataset (WBD),

    modnr.maps.arcgis.com/apps/webappviewer/index.html?id=f64fdeef041e4afda6a125afbd1

    92e8f.

"Rivers and Streams." *MDC Discover Nature*, nature.mdc.mo.gov/discover-

    nature/habitats/rivers-and-streams.

Teller, Suzanne. "Save Our Streams." *The Izaak Walton League of America: Outdoor America,*

    2014, pp. 24-37.

Edrington, Tom S., and Todd Riley Callaway. *On-Farm Strategies to Control Foodborne*

    Pathogens. Nova Science Publishers, Inc, 2012. *EBSCOhost*,

    drury.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nle

    bk&AN=541680&site= ehost-live.

Irwin, John. "Optimal PH Requirements for Different Species." *Minnesota Commercial Flower Growers Bulliten*, ResearchGate, 2002, www.researchgate.net/publication/328758707_Optimal_pH _requirements_for_different_species.

Renwick, William H., et al. "Water Quality Trends and Changing Agricultural Practices in a Midwest U.S. Watershed, 1994-2006." *Journal of Environmental Quality*, vol.37, no. 5, 2008, pp. 1862-74. *ProQuest.*

Widiastuti, E., et al. "The impact of the local dairy cattle farm toward the river water quality in Gunungpati Subdistrict Central Java." *International Journal of Science and Journaling,* vol. 8, no. 1, 2015, pp. 15-21. *ResearchGate.*