The Farmer and the Flood: An Exploration of Flood Management in Missouri

Senior Honors Thesis

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by
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Abstract

In the history of agriculture, the United States’ Corn Belt has been one of the most altered and intensely cultivated regions in the country. In the spring of 2019, the region was inundated with extreme rainfall. These rain events led to severe flooding causing damage to levees, communities and agricultural lands, totaling billions of dollars in damage.

This thesis will focus on the complexities of the flooding in Missouri. This thesis has two aims. The first, to explore the history of agriculture and levee flood management in the region, and the second to interview farmers impacted by flooding in Jackson County, Missouri. Information from interviews conducted in the county will be used to assess both sides of the flood management debate and recommendations for sustainable best practices will be made.

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Introduction

After a season of unprecedented rainfall in June 2019, the levee in Levasy, Missouri finally broke. Water began to flow fast across the tilled fields. The corn crop had already been devastated from earlier rainfall, but now, the rows were barely visible.

The water reached the foundations of the nearby homes. As the water began to rise, so did all of the insects hiding in the concrete. Family photos, treasured heirlooms, and memories were destroyed in just hours.

Farm machinery and automobiles became engulfed in flood waters. Murky, brown water carrying dirt, chemicals, and pesticides continued to spread. By mid-day on June 1st, Highway 24 became impassable as it became submerged by floodwaters.

Jackson County is just one example of the damage of flooding in Missouri in 2019 with two levees that broke. Why do we keep building levees and farming in the floodplain? This paper will explore the debate about whether we should continue to build and repair levees or simply let the river go back to its natural state and flood. In order to fully understand both sides of this debate, this paper aims to explore the history of the levee system and farming in the floodplain, as a means to determining best agricultural management practices that support both the farmer and the land.
Chapter 1: Natural History of Missouri

Geology of Missouri

The Missouri river bisects the state into northern and southern halves. The northern portion of the state is a combination of glacial drift, sediment formed by glacier melt, and loess, which is sediment formed by wind-blown dust through glaciation during the Pleistocene. The southern portion of the state is a limestone terrain characterized by caves, springs, and trees. The geology of these two regions has truly shaped the character of the state today. The southern geology is much more mountainous and rough, while the northern geology has ideal conditions for farming and grazing.

Both regions have a deep bedrock, allowing for increased production of the land. Both regions are also prone to erosion and flooding due to their geologic features, although the northern region is more prone to flooding due to the prevalence of intensive agricultural production throughout the region.²

Geology of Northwestern Missouri

This thesis will investigate flooding impacts of the Northwestern portion of the state. The Northwestern region of Missouri is abundant in agricultural production. The topography of the region varies between nearly level, gently rolling glaciated till plains and hilly loess plains.

Mollisols, soils of grassland systems and Alfisols, which are soils of hardwood forests, are dominant in this region. Soils here have mesic temperatures with averages ranging from 8°C to 15°C. These soils have udic soil moisture, which is common in humid environments. Udic

soils retain soil moisture from rainfall. The amount of moisture retained in the soil can be equal to or exceed the amount of evapotranspiration in the environment, which is the sum of water evaporation from soil and plant transpiration. Thick loess from wind-blown silt and glacial till cover Mesozoic and Paleozoic era shale, sandstone, and limestone in the region. The combination of thick loess and glacial till creates a porous soil that allows water to easily pass through it. This type of soil does not handle floods well, especially when it loses organic matter due to agricultural production. This soil type is more prone to losing organic matter due to its porous characteristics. As soil is continually tilled and degraded, sediment yields increase as more water passes through. For this combination of soil, it is especially important to take preventative measures to decrease sediment yields, as this region is especially prone to flooding due to agricultural and residential development in the Missouri River floodplain.

**Ecoregions of Northwestern Missouri**

The U.S. Environmental Protection Agency divides the Corn Belt region into three ecoregions. Missouri, specifically the area of Jackson County, which will be studied in this thesis, is classified in the third ecoregion: Western Corn Belt Plains.
The climate of this region is classified as mid-latitude, humid continental climate with hot summers and cold winters. The mean annual temperature of this ecoregion is 6°C in the North to 12°C in the South. The frost-free period of the region ranges from 140 to 200 days.

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The mean annual precipitation is 800 mm, ranging between 610 and 1,000 mm. Precipitation mainly occurs during the months of the growing season.

The ecoregion’s vegetation has been drastically altered. Originally, the region was characterized by tallgrass prairie covered with native grasses and small patches of oak-hickory woodlands. Today approximately 75% of the region has been converted to cropland. The remaining 25% land cover is pasture and woodlands. In comparison to the ecoregion, Jackson County, Missouri’s land cover is 69% cropland, 18% pastureland, and 7% woodlands. Jackson County has more pastureland than the ecoregion as a whole.

Hydrology of Northwestern Missouri

The hydrology of the region is characterized by intermittent and perennial streams, many of which have been channelized. Channelization is the process of redirecting streams. This process is done by artificially modifying or constructing a stream bed. Channelization can also occur as a result of the construction of levees and dams.

Channelization in this region has occurred mainly due to agricultural production and the construction of residential properties. Channelization commonly occurs through the draining of wetlands and floodplains. Many of the agricultural properties in the Northwestern region of Missouri are in drained floodplains.

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5 The remaining 6% of agricultural land is classified as “other”.

Channelization is extremely helpful in allowing for agricultural use of the land, but alteration of hydrology has consequences: It damages natural habitats and natural buffers of streams. Channelization also disrupts natural flood patterns which can result in excessive sedimentation accumulation downstream because fertilizing sediment no longer can be deposited on river banks. In addition to the disruption of natural flood patterns, channelization allows for water to move downstream from uplands faster. Due to less flood storage capacity in the uplands of the watershed, the water flows downstream at a faster rate. As channelized streams interact with high levels of rainfalls, this leads to flash flooding.

Few areas in the Northwestern region have natural lakes, as most lakes and ponds in this region are man-made and are used for agricultural purposes. Water from these lakes and ponds are pumped onto fields or serve as a water source for livestock. Surface and groundwater contamination from fertilizer and pesticide application is a large issue in this region. Livestock production is also a large contributor to contamination.\(^7\)

**Surface Hydrology of Northwestern Missouri**

Missouri is a unique state due to it being the meeting place of four river basins: the Missouri River Basin, Upper Mississippi River Basin, Arkansas White Red River Basin and the Lower Mississippi River Basin.

The connection of these river basins is important, as this connection contributes to flooding throughout the region. When levees break and agricultural properties are flooded, nutrients such as nitrogen and phosphorus pollute the water. These chemicals pose a threat to public health, but also pose a threat to the ecological health of bodies of water and can cause hypoxia, a loss of oxygen. In extreme cases, chemicals can create large zones of hypoxia in bodies of water, these are referred to as dead zones. The largest dead zone in the world is found in the Gulf of Mexico. The size of the dead zone fluctuates annually due to several factors, such as rainfall. When increased rainfall events occur, such as the historically high rainfall in 2019, more water flows through the Mississippi River Watershed which discharges into the Gulf of Mexico.

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Algae thrives from nutrients that are carried from the watersheds of Missouri and surrounding states. This creates algal blooms and eutrophication\(^9\) which reduces dissolved oxygen availability.\(^10\)

In 2019, the dead zone reached 6,592 square miles. The average dead zone size in the Gulf of Mexico is 5,770 square miles.\(^11\) Above average floodwaters fuels a larger dead zone.

![Fig 3, 2019 Gulf of Mexico Dead Zone, Source: NOAA\(^12\)](image)

The Gulf of Mexico’s dead zone has increased over the years due to the intensification and commercialization of agriculture in the Corn Belt. The next section will delve into how Missouri became the agricultural hub that it is today through an exploration of its agricultural history.

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\(^9\) Eutrophication is caused by an excess of nutrients in a body of water. These nutrients lead to an increase of plant growth, but kill animals due to a lack of oxygen.


\(^12\) Ibid.
Chapter 2: Agricultural History of Missouri

Northwestern Missouri’s Agricultural History: The Osage Nation and Pre-Colonial Agriculture

Prior to European contact in the early eighteenth century, Missouri was predominantly controlled by the Osage nation. The first to alter the landscape in Missouri were mainly Native Americans, who burned the hardwood forest of Missouri, opening up grasslands in the state.  

Native American farming in Missouri was primarily subsistence farming. Common crops included maize, beans, pumpkins, squashes and melons. The Osage used the Three Sisters Method, the companion planting of corns, beans and squash. Fields and small garden plots were commonly bordered by sunflowers.

Tribes created subsistence garden plots. These plots were mainly run by women with the assistance of younger children. Crops were not rotated, however Native Americans often allowed fields to lie fallow for several years and would burn brush and trees on the plots. This burning served two purposes: weed seeds could be destroyed, and the ash from the brush and trees served as a form of fertilizer. The Osage traditionally planted in river bottoms and floodplains. These soils were thought to be the most fertile and allowed for a bountiful harvest.

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European contact shifted the subsistence lifestyle of the Osage to a market and trade economy. The Osage continued managing small farm plots but also moved into the woodlands for hunting. Fur of bison, deer, and the occasional beaver served as a profitable good for trade with European colonizers.\(^{17}\)

At the end of the eighteenth century, the lifestyle of the Osage Native Americans had shifted into becoming semi-nomadic. Less time was devoted to managing land and agriculture, as there was more pressure and demand for fur and goods. Women continued to practice subsistence farming of small farm plots, while men’s attention shifted to the hunt.

**Nineteenth Century Agriculture in Missouri**

In the mid-eighteenth century, the French began to make settlements in Missouri. During this period, there was fluctuation in control of the land between France and Spain. French settlements began in Eastern Missouri and around St. Louis. Settlers who secured land grants often settled by rivers and streams. In order to secure a grant, French settlers had to guarantee that the land would be used to produce some needed agricultural commodity.

The early days of French settlement, beginning as early as 1735, were quite simple and primitive farm tools were commonly used. Grain was commonly cut by hand and plows were commonly made from timber.\(^{18}\)

Farmers who had been issued smaller land grants often used their land to produce wheat for their family’s bread, corn for the farm animals, vegetables, and cotton for family clothing. Farmers who received larger land grants used their land for profit, rather than for subsistence.

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These farmers often raised cattle, horses, and sheep. As forests and land cleared, these farmers also began planting large fields of corn and wheat.\(^{19}\)

French settlers were not the only ones occupying the land, land was also occupied by Spanish settlers. Additionally, Missouri attracted pioneer American farmers coming from Kentucky, Ohio, Virginia and Pennsylvania.\(^{20}\) These pioneers were the first of a large westward expansion of eastern farmers who came to Missouri between 1783 and 1830. By 1803, as a result of the Louisiana Purchase, the land became controlled by the United States. The farmers mainly practiced homestead agriculture, building homes from scratch and clearing their own land by hand, axe and wooden plow.

These farmers practiced subsistence agriculture, planting corn, potatoes, and garden vegetables for their families. In addition to subsistence agriculture, market production began to develop during this time. Pigs often foraged in the forests and woodlands, while cattle, sheep, and horses grazed in fields.

Subsistence agriculture was based “on the rich soil created by river floodplains”. Along with the development of floodplains, riversides were cleared of their trees and natural buffers. Throughout the antebellum period, settlers struggled with flooding of the Mississippi and Missouri rivers. In 1824, a family rode horses into their flooded corn farm and reached down under flood waters to pull up stocks for harvest. 1826, 1844, and 1856 were particularly devastating years for flooding and “brought a conjunction of economic and bodily harm.”


\(^{20}\) Ibid.
Flooding not only washed away topsoil, but stagnant waters lead to miasma. Families that did not move to higher ground often perished due to flooding:

The frightening sounds of a ‘booming flood’ signaled great danger—the falling in of many acres of heavily timbered riverside… When rivers rose to overflow their banks, landscapes were transformed: high places became islands, the stench of rotting flesh and vegetation blanketed huge areas, the normal noises of woodland or field were silenced, and even fierce predators became cowed in the ceaseless damp.

As farming shifted from subsistence to larger development and commercialization, agriculture in the floodplains would continue to pose a threat to farming and public health.

A Change in Agriculture: Commercialization

The period between 1830 to 1860 saw great agricultural transformation and change. Agriculture shifted from subsistence farming to farming for business. The bottomlands of the state were still documented as swamp in 1836. Beginning in the mid 1830's, land was drained as settlers migrated to their new home. European settlers drained the land by digging ditches and laying tiles in the plains. The development of farm machinery allowed for land to be cultivated more quickly and efficiently. Trains allowed for the transport of crops and other farm produced goods. New technology also allowed for the improved domestication of farm animals. These animals were able to graze on fields which had been cleared by axe. New machinery

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21 Miasma is a smell so strong that it was associated with diseases such as cholera. In the beginnings of public health, miasma was often associated with extremely contagious and deadly diseases.
23 Ibid., p.142
24 Ibid., p.145
25 Ibid., p.145-147
began to be developed during this era. As farm methods became perfected, the price of land in Missouri became more valuable and desired.

As more settlers moved to the state, they brought their cattle along with them. Crossing the rivers throughout the state posed a challenge, with many cattle lost in the river. Although once crossed, it was worth it. The land in the state was well-watered, native grasses were bountiful, and timber was readily available. All of these elements allowed for a successful cattle industry. In the 1830’s, local leaders urged farmers to improve their cattle stock. The most common breed of cattle at the time was Durhams. County fairs became popularized and common during this time, allowing for encouragement of competition among breeders and farmers. The California gold rush in the late 1840’s increased the demand for beef cows. Cows were bought in Missouri for $10 and sold in California from $100 to $150 per head. As more mines opened in the west, cattle drives became more common. In the 1850’s, Spanish Fever spread from cattle drives killed thousands of stock in Missouri. As a result, states passed laws to control cattle drives to limit the spread of disease. The cattle industry was in a state of disarray when the Civil War began.

During the civil war, the cattle industry in Missouri continued to suffer as a result of farmers being called to serve in the war. Soldiers who were injured and could no longer fight in the Civil War returned home to Missouri to work in agriculture. These soldiers were an important factor in the development of agriculture across the state.

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the Civil War, beef cows were in high demand as construction crews building railroads needed sustenance.

The cattle industry began to bounce back, as did overall agriculture in Missouri after the Civil War. Machinery allowed for the average yield per farm to increase, as farmers could cultivate more acreage. Corn and wheat quickly became the two staple crops of Missourian agriculture. Specialized agriculture became popular in Missouri, with many farmers focusing on these two staple crops.  

Missouri’s Role in the Corn Belt: Early Years

Beginning in the mid 1840’s and 1850’s Missouri became classified as part of the Corn Belt. The Corn Belt is classified as a region in which corn and other crops are intensely produced. Corn in the Corn Belt region was initially produced for the purpose of livestock feed. States traditionally considered to be part of the Corn Belt are Nebraska, Iowa, Missouri, Illinois and Indiana. North Dakota, South Dakota, Kansas, Minnesota, Wisconsin, Michigan, and Ohio are states which are also associated with the Corn Belt.

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Missouri’s first counties to be considered part of the Corn Belt were in Little Dixie and Osage Plains. Successful corn crops were produced on both prairies and drained land. The most productive land in the region was, and still is, originally wetlands and floodplains. Agricultural production in Missouri’s first Corn Belt counties: Little Dixie, flourished, as a result of slavery.


34 Ibid., p.144

35 Ibid., p.13

36 Ibid.
Slavery and Northwestern Missouri Agriculture

Slavery was an unfortunate but large contributor to the success of Missouri agriculture. Some of the highest populations of slaves were found in a region of Missouri referred to as Little Dixie. These counties were especially known for their agricultural contributions and used slave labor.  

Figure 4, Little Dixie Counties based on Hurt (1992), Source: Benée Hershon

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Due to the amount of slave labor and agricultural success in the region, Little Dixie became one of the first counties to be considered part of what we know today as the Corn Belt. A majority of the settlers of Little Dixie had moved to the region from the Upper Southern states.  

Corn, however, was not the only crop that Little Dixie was known for. Slave labor was used in the region to produce high quality tobacco and hemp. The tobacco industry in Little Dixie had a slow start due to poor preparation and handling for the market.

It was believed that the combination of rich soil, climate, and access to the Missouri River would help the region achieve an abundant tobacco crop, despite the poor start to Little Dixie’s tobacco industry. John R. Bohannon, a farmer in Little Dixie’s Howard County wrote about this potential, stating, “a market was at every man’s door.” Following the financial crisis known as the Panic of 1837, farmers began to increase planting of tobacco. In 1843, the state legislature passed an act to provide public tobacco warehouses. Inspectors would label and review tobacco before it went out for trade. These warehouses truly helped ensure the success of Little Dixie’s tobacco market. Although tobacco was an abundant crop, Little Dixie’s tobacco industry suffered after the Civil War and eventual emancipation of slaves. With the tobacco industry dead, farmers turned to focusing on crops, such as corn and wheat. The Morrill Act of 1862 was passed in the middle of the civil war as agriculture suffered as a result of warfare. It created the land-grant university system for agricultural education, research, and support, and set the stage for the encouragement of the development of agriculture throughout the next century.

38 Ibid., p.26  
39 Ibid., p.90-97
World War I and Missouri Agriculture

Missouri agriculture flourished during World War I, and farmers reaped the rewards. Food demands in Europe resulted in an increase of crops bought from Missouri. This era was known in the United States as the farmer’s golden age. During this era, perceptions of agriculture shifted and there was an increase in hopefulness that agriculture would continue to be successful, and crops would continue to be in demand. In 1916, the editor of the *Knox County Democrat* wrote:

> Upon him [the farmer] will devolve the vast amount of supplies demanded by the world when this war ends. His will be the burden of feeding the millions of mouths that will be hungering for the products of the farm. And his will be the pockets that will sag with the weight of gold that pays for these supplies.  

Agriculture became more important during the war era and more people pursued agriculture as a career. Between 1895 and 1900, the University of Missouri College of Agriculture had an average of two graduates per year. In 1915, the school enrolled more than 1,000 students. Agricultural science became more in demand and agricultural research increased during this era.

Farmers began to seek guidance from agricultural colleges and extension schools. Frederik B. Mumford, dean of the University of Missouri College of Agriculture, encouraged farmers by saying, “aid the U.S. with larger crops.” These schools, along with local governments, encouraged farmers to grow larger quantities of crops to support war-time efforts.

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41 Ibid.
42 Ibid.
The Great Depression Era and Missouri Agriculture

The Great Depression, beginning in 1929, took an economic toll on the nation and the nation’s farmers. Since the mid-1920’s, the agricultural economy was already beginning to decline but was devastated by the Great Depression. 43

From 1929 to 1932, the per capita income of Missouri dropped by 44.1% and was $621. 44 In the 1930’s, agriculture played a much larger role in the economy than today. This is attributed to other parts of the economy which have grown, such as manufacturing. In the 1930’s, farmers were key contributors to the nation and were a large political force. 45

Although Missouri is not a state considered to be impacted by the Dust Bowl, the state did experience drought conditions in the mid-1930’s, with substantial drought impacting especially the Northwestern portion of the state. 1934 and 1936 were severe drought years. 46

The New Deal in Missouri

As the agricultural economy plummeted and farmers faced drought, excess production and falling prices made problems worse. 47 In response to the issues farmers faced, the Roosevelt administration passed a series of New Deal policies to aid farmers.

Examples of such policies include the Agricultural Adjustment Act (AAA) of 1933, which encouraged farmers to take acreage out of production. Farmers who did this received payment for the goods they would have produced on that acreage. The act stabilized farm prices and limited production. This not only benefited farmers, but the soil health of acreage, which was taken out of production. By 1936, farm prices began to rise as a result of the AAA and other new deal policies.

An example of another New Deal institution which benefited farmers—especially farmers in Missouri—was the Civilian Conservation Corps (CCC). The CCC, established in 1933, employed over three million young men. The CCC performed manual labor across the country and is perhaps most well-known for expanding the National Park system by building trails. The CCC also replanted grazing lands, drained swamp land, built levees, and protected farmland across the country from flooding and erosion.

New Deal policies also created the Soil Conservation Service (SCS) in 1935. The SCS encouraged farmers to take care of their soils. Measures which were encouraged included crop rotation, following contours in the land when plowing, terrace sloping to prevent erosion, and the planting of trees to guard against wind erosion. The SCS continues to do important conservation work today as the Natural Resources Conservation Service (NRCS). The SCS also encouraged the development of Soil and Water Conservation Districts. The Missouri State Soil

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48 Ibid., p. 15
49 It is important to note that the Supreme Court ruled the AAA as unconstitutional in 1935. The AAA is a contentious topic, but ultimately led to a rise in the agricultural economy.
and Water Districts Commission was created in 1943 to carry on the conservation services, which had been developed in the New Deal Era.\textsuperscript{51}

The Farm Security Administration (FSA), which was also created in 1935, supported farmers in providing loans to buy and keep their land. Although the FSA no longer exists, its mission and work in combination with other agencies is now the Farm Service Agency today.

By 1939, the Missouri per capita income had risen by 50.90\% from the per capita income in 1932.\textsuperscript{52} This rise in income can be attributed to New Deal institutions and policies that supported farmers during this era. Farmers who had been struggling since before the Great Depression were back on their feet and back in production. New Deal policies laid out important roots for today’s agricultural conservation policies and organizations.

\textbf{World War II and Missouri Agriculture}

Advancements of chemical technologies, which were initially developed during the World War I era, allowed for the industrialization of agriculture after World War II. Nitrogen fertilizers and pesticides became cheap and more accessible to farmers. Monoculture farms became increasingly common, producing large quantities of one or two crops to aid in war-time efforts.\textsuperscript{53}

\begin{itemize}
\item \textsuperscript{51} History. (n.d.). Missouri Soil and Water Conservation Districts. Retrieved From: https://mosoilandwater.land/franklin/history
\end{itemize}
Small family farms, although still present across the state, lost business as larger family farms began to utilize subsidies from state agencies to expand and generate more profit. Additionally, larger farms utilized new technology and practices from Land Grant Universities. Land Grant Universities began employing extension agents, whose job it was to relay information and guidance to farmers in specific counties they were assigned to. Farm numbers across the state began to drop after the war as larger farms took over. During this era, the family farm became a distant symbol of the past, while large, industrialized farms became the vision of the future of agriculture.

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Chapter 3: Agriculture in Missouri Today

Missouri’s Role in the Corn Belt Today

As of 2019, there are 95,320 farms across the state of Missouri. Missouri’s top five commodities are soybeans, corn, cattle, calves, hogs, and broilers. 261 million bushels of soy are produced in Missouri annually, and 466 million bushels of corn are produced annually. Missouri is not the top producer of corn in the Corn Belt, but is a large contributor to corn production.

Missouri’s top exports are to Canada, Mexico, the European Union, China, and Japan. In 2019, Missouri generated $243 million in soy exports and $136 million in corn. The USDA estimates that 54% of land in farms is cropland, while 25% is pastureland.

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55 A breed of Chicken
56 Missouri Ag Highlight. Missouri Department of Agriculture. Retrieved From: https://agriculture.mo.gov/topcommodities.php
Missouri’s agricultural economy is dependent on exports, especially exports to China, which have been heavily impacted by the China-United States trade war that began in 2018. As a result of tariffs imposed on Chinese imports, China has retaliated with tariffs on soy imports from the United States.⁵⁹


Missouri Agricultural Production Today

Historically, the Corn Belt has always fed heavily on the land which supports it. Today, agriculture in Missouri is an $88 billion industry. There are 95,320 farms across the state, employing more than 378,232 people. Agriculture is Missouri’s top industry and contributes to 10.5% of Missouri’s total employment. This percentage includes farmers, agricultural sales professionals, agricultural technicians, and scientists.

Intensive, monoculture production is a commonality in big agriculture. Soil erosion occurs on farms, but is typically a gradual process and a combination of the soil’s exposure to the elements and farm machinery. The process of soil erosion is sped up when a lack of diversity of crops is planted and when a farm becomes a monoculture, planting only one type of crop.

Monoculture and intensively tilled soils have higher sediment yields, meaning that more water can pass through the soil during rainfall events, and more soil is carried away. Many farms have adopted sustainable agricultural methods. By implementing these methods, soil mass can be built and sediment yields can be minimized, allowing less water to pass through. Maximum protection can only be achieved through adopting sustainable measures upstream, in order to

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protect farms downstream. Many farms in the state have not implemented these measures, thus relying on the protection of levees from flooding instead. Relying on levees alone has led to devastation throughout the Midwest and Missouri, especially during The Great Flood of 1993.
Chapter 4: Flood Mitigation through Time

Flooding and Mitigation: The Great Flood of 1993

The state of Missouri is no stranger to the issue of flooding. Missouri has had many seasons of flooding. One of the historically worst flooding events in U.S. history occurred in 1993. The 1993 flood is often referred to as “The Great Flood”.

The 1993 flood was not caused by one single rainfall, but by a three-month period in the summer of 1993 of above average rainfall events. Leading up to the summer of 1993, the fall of 1992 had been a wet one. The winter of 1993 also had above average snowfall. These factors combined, led to soil already being saturated prior to the summer.65 The soil in the summer of 1993 was simply unable to retain any of the water. In addition to poor soils, multiple levees across Missouri and the Midwest broke. The states impacted by the 1993 floods were Missouri, Iowa, Illinois, Nebraska, South Dakota, Kansas, North Dakota, Minnesota and Wisconsin.

In Missouri, 101 out of 114 counties were declared FEMA presidential disaster areas. Missouri received the highest amount of FEMA disaster relief funding during the 1993 floods out of any other Midwestern state that had been impacted.

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During the 1993 flooding events, Missouri experienced extremely high levels of crop and residential damage. Missouri also received the highest amount of insurance money out of any state impacted by the 1993 flood. In total claim payments for farm and residential properties, Missouri received $171,938,390, with an average claim payment of $32,313.

FEMA’s National Flood Insurance Program (NFIP) offers the Community Rating System (CRS) Program. The goal of the CRS program is described as, “a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements”.

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67 FEMA. “National flood insurance program community rating system”. Retrieved From: https://www.fema.gov/national-flood-insurance-program-community-rating-system
In 1993, only 5 communities in Missouri participated in the CRS program. From June 1993 to April 2003, the number of communities and residential properties implementing hazard mitigation projects increased. Although the number of hazard mitigation projects increased, many of these projects were located near urban centers rather than in rural parts of the state where the majority of agriculture takes place.
Hazard Mitigation Projects from June 1993 through April 2003 per County for the Great Midwest Flood Region

Fig 8, Hazard Mitigation Projects. Source: FEMA

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In 2008, Missouri had another particularly bad flooding season. This flooding season is not comparable to 1993, as the amount of damage was much smaller. During the 2008 flooding events, it was found that counties that were hit hard in 1993 fared well in 2008. The program’s success in participating communities can be attributed to awareness of flooding, mitigation efforts, and plans. Mitigation efforts include structural improvements to levees, education, and ensuring proper policies are in place for emergency prevention. Mitigation in one community can cause more flooding downstream in other communities that have not adopted CRS measures.

Although the levee system in Missouri is old and continuously fails, mitigation efforts alone through the FEMA CRS program has shown to make a difference. As of April 2019, 13 communities in Missouri participate in the CRS program, including Kansas City in Jackson County. In a state which is prone to flooding events, 13 communities in the CRS program is not enough, the program must be expanded. Although this program has made a difference, it is simply not enough to mitigate flooding. To maximize effectiveness, communities upstream and downstream must join the program.


Climate Change and Flood Mitigation

Both the FEMA CRS Program and Hurricane Katrina created a heightened awareness of flooding and mobilized efforts to create mitigation plans. Despite these mitigation plans, the Missouri levee system overall has had few improvements. Fixing a levee which breaks every other season is not an effective strategy. Without action, mitigation plans are simply plans. Since 1993, the mean temperature over land and ocean has continued to increase due to climate change.

![Mean Temperature over Land and Ocean since 1880, Source: NOAA](image)

**Fig 9, Mean Temperature over Land and Ocean since 1880, Source: NOAA**

One of the biggest factors contributing to a warmer ocean is warming temperatures due to climate change and the emissions of carbon dioxide, methane, and other greenhouse gases.

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Global Climate Change. *University of California Riverside*. Retrieved From: https://globalclimate.ucr.edu/resources.html
which trap heat and create a greenhouse effect. Warmer oceans create stronger and more frequent rain events.

Figure 10, Warm Ocean Temperatures and Strength of Storms, Source: Emanuel (2007)

In a study on changing rain patterns in the Amazon, researchers found that the Atlantic Ocean has a large role. Strong warming in the ocean greatly and rapidly increases the evaporation of water into the atmosphere.

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74 Ibid.
As the impacts of climate change become more visible through extreme weather events, flooding events have the potential to continue to become more common in Missouri and throughout the Midwest. Many refer to the floods which occurred in 1993, 2008, and 2019 as “500 year floods,” as in the enormity and damage of these floods only happen every 500 years. The consistency of these events over the past three decades has proven that these events are far from a rare 500-year event.

Other factors influencing both climate change and the agricultural industry is population growth. The world population is projected to continue to rise throughout the century. As

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Footnote:

population continues to increase, many turn their hope to farmers who will supply food to feed the world.

![World Population Projection](image)

*Fig 12, World Population Projection, Source: Gerland (2014)*

Farmers are tasked with the responsibility of feeding a growing world population, but flooding in 2019 did not cause food shortages or even a shortage of corn. The reason that the United States does not experience these shortages is because the corn that is being grown in the Midwest is not all contributing to food production. A large percentage of corn being grown is produced into ethanol and feed. 38.3% of corn produced in the United States in 2017 went to

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ethanol production. From 2016 to 2017, there was a 100 million bushel increase in corn production for ethanol.\textsuperscript{78} 38.1% of corn was allocated to feed for cattle and livestock in 2017.

However, as the global population rises, so likely will fuel and cattle demands. An increase in fuel demands will contribute to an increase in corn production, which will cause damage to soil, allowing for soil to become more easily flooded during rain events. Corn will be turned into ethanol, and the production and burning of ethanol will create more carbon dioxide emissions. Corn produced for feed will go to cattle which produce methane, leading to more methane emissions as well. The cycle of climate change and flooding will continue unless practices are adjusted. In the meantime, Missouri has combated the issue of flooding with the construction of levees.

\textsuperscript{78} Batres-Marquez, S. Patricia. (2018). Corn Use for Ethanol in 2018/19 Updated Down, More Sorghum for Ethanol Expected. \textit{Agricultural Marketing Resource Center}. 
Chapter 5: “If it keeps on raining the levee’s goin’ to break”

Levees

A levee is a man-made structure designed to contain and control the flow of water in a river to protect land from flooding. In the past, levees were often constructed by private citizens, although today they are designed by engineers and federal and state laws require that they be certified and inspected.

Levees are typically concrete or earthen constructed. Unlike a dam, which has water on both sides, a levee has water on one side and land on the other. With each flooding event, the levee needs re-inspection and constant upkeep which is no cheap task.

In Missouri, levees are not commonly paid for by the federal government. Levees are maintained and the responsibility of towns, groups of farmers and some are the responsibility of the U.S. Army Corps of Engineers.

Why the levee system?

The way in which land was developed in Missouri poses a challenge to flood management today. As much as one tries to change nature, the floodplains still inevitably flood.

Floodplains are natural low-lying areas beside rivers. Floodplains are formed from thousands of years of sedimentation build up and layers of silt from the breaking of a rivers bank.

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79 Referencing the Led Zeppelin song “When the Levee Breaks”, originally a lyric from “When the Levee Breaks” by Kansas Joe McCoy and Memphis Minnie.
81 To avoid getting lost in the what is the difference between a levee, dike and dam: Levees protect land that is typically dry and floods during rainfall events, while dikes protect land that would naturally be underwater a majority of the time.
The floodplain is flat land that is rich in minerals from the outwash of the river. In addition to rich minerals, the floodplain is an ecologically valuable riparian zone. The river carries organisms and macroinvertebrates that aid in creating a rich soil through their waste.

The rich minerals in the soil of a floodplain make it especially attractive and fertile for agricultural land. The flatness of a floodplain also makes it easy to develop. Instead of having to level rough and uneven terrain, the river has already provided that natural service to the area of the floodplain.

This is not a unique problem to Missouri. Throughout the nation, as states were developed, it seemed easier, effective, and cheaper to develop the floodplain and create man-made controls of the river. The issue with developing a floodplain is that the floodplain still floods. It not only still floods, but development disrupts the natural ecological processes of the river. Development of the floodplain constricts the river and can make flooding even worse.

When a river is constricted and there is a large amount of rainfall, it causes the river to rise even faster when the river has no room to spread out across the floodplain.

**History of the Missouri River**

In order to understand the impact of the Missouri Levee system on agriculture, one must first understand the history of the Missouri River itself. During the Pleistocene epoch, glaciers that spread from Southern Canada to the Northern United States shaped the Missouri River.

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82 Riparian zones are areas of land and vegetation between rivers and streams. These zones are rich in biodiversity and often buffer pollutants from entering bodies of waters.

Glaciers shifted the Missouri River’s drainage into the Mississippi River, while previously, drainage was north of the Missouri River.

Beginning in 1824, Congress dedicated funding to the U.S. Army Corps of Engineers to clear the Missouri River. Clearing the river often involved removing large trees along the river bed and other obstacles in the river bed itself.

As development in Missouri expanded in the 1850’s, the Missouri River began to be altered. The river was and still is a source of trade routes. Levees were built to protect development and farmland in the river bottoms. In order to ensure successful trade and protection from the river, the river was dredged. A goal of navigability became a key focus of the U.S. Army Corps of Engineers. In addition to dredging, dams were built to raise water levels so that barges and boats could successfully navigate the river.

By 1904, irrigation became a focus on the Missouri River. The river could provide irrigation to farmers in Missouri, but also throughout the entire Missouri River basin. During this period, more dams, diversion structures, and pump stations were placed along the Missouri River and its tributaries as a way to store water or shift it to agricultural properties.\(^\text{84}\)

As the river continued to be altered to accommodate for development, traffic on the Missouri River slowed down during the Great Depression. During the Great Depression, the Missouri River was seen as an opportunity for both hydro-power and a water source to bolster the economy and spread prosperity into arid states that had suffered from drought.

In 1933, the National Industrial Recovery Act (NIRA) was passed so that the Roosevelt administration could control public works projects. The first major task under NIRA, was to

construct the Fort Peck Dam on the Missouri River, which was completed in 1939. The dam is far upstream from Missouri, located in Montana. Although the Fort Peck Dam is not the largest dam on the Missouri River, the dam set a precedent for the construction of other large dams\(^5\) that have changed the natural flow of the river. The dam was built with the potential to store 19.5 million acre feet of water. The Fort Peck Dam was a crucial step in the development of the river and opened the possibility to further development throughout the entire river basin.

Following the construction of the Fort Peck Dam, the Bureau of Reclamation and the U.S. Army Corps of Engineers developed two separate plans to bring water from the Missouri River out west, this plan is referred to as the Pick-Sloan Plan.

\(^5\) Such as the Garrison Dam, located in North Dakota. Although my knowledge of hydrology is limited, the construction of these large dams has changed the natural flow and levels of the river. USGS has conducted a great deal of research on the impacts of individual dams, but is beginning to consider the greater impacts of an entire system of dams on the Missouri river. For more information: https://www.usgs.gov/news/connected-consequences-river-dams
The plan involved building a series of large dams to transfer water between river basins. In addition to benefiting agricultural lands, the plan would also provide thousands of construction jobs.

The two plans were still separate after the construction of the Fort-Peck Dam in 1939 and did not become unified until 1944 as a result of the Flood Control Act. The Pick-Sloan Plan required construction of more dams and reservoirs. The act determined that the U.S. Army Corps

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of Engineers would build and operate the mainstem dams of the project and the Bureau of
Reclamation would allocate water for irrigation.

In addition to settling the Pick-Sloan Plan, the Flood Control Act also made flood-control
structures such as levees that would be built as a result of the project, in Kansas and Missouri,
the responsibility of the U.S. Army Corps of Engineers.  

The Pick-Sloan Plan not only altered the state of the Missouri River itself, but was a
crucial chapter in the development and flood control plans of the river. The Pick-Sloan
construction plan created a regulating system with the dams to prevent releases from damaging
flows downstream. Although a regulating system was created, it did not completely prevent
flooding. The regulating system of dams from the Pick-Sloan plan alone could not control the
amount of volume from rainfall, which comes downstream. Pick-Sloan set a precedent of the
further altering of the river which we see today through the construction of dams and levees.

**History of Missouri Levee System**

As far back as the mid 1800’s, the Missouri Levee system was the subject of debate. In
the eyes of most, the levees were thought to be a necessity to protect communities, farmland, and
property from flooding. When a town or city was created, so was a levee. The levees became
synonymous with insurance. It made sense to construct a levee to protect the newly built towns
and cities. The construction of levees came with a false sense of security, as levees created a
much greater problem downstream.

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Beginning in 1846, the U.S. Corps of Topographical Engineers began conducting surveys in the Midwest to assess how to control the rivers to support the agriculture and industry that was thriving in the region. By 1863, the Topographical Engineers merged with what we know today as the U.S. Army Corps of Engineers. The Army Corps of Engineers designed the first large scale flood management programs in the nation. The levee system was initially seen as a miraculous idea. The original levees in the region were constructed by everyday people who had converted non-productive land in alluvial flood plains to fertile farmland, although many floodplains in what once was Osage territory had already been farmed in the past and were simply taken over by settlers. The U.S. Army Corps of Engineers had the power and funding to help expand this conversion. State legislators in Missouri and other Midwestern states petitioned Congress to assist in flood management. The argument was that investing in levees would be an investment in the United States economy. The levees were costly, but the success of farm production would outweigh that cost and simultaneously feed the nation. In 1849 and 1850, Congress passed the Swamp Lands Act. The act donated public land which was frequently flooded by the rivers to the state government, so it could be sold to investors and that money could be used for flood control. These investors were comprised of farmers who would drain the land and construct levees to protect it and also investors who would buy the land, drain it and sell it to farmers. The state received funds from these purchases that could be reinvested into the levee systems. As a result of the Swamp Lands Act, Missouri received three million acres.

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90 Ibid., p.10

91 Little research has been conducted on what happened to this acreage in Missouri. The act was originally created to develop agricultural land in the Florida everglades and swamp lands in Louisiana. There was little government oversight over these lands, and many states used this act to destroy ecologically significant wetlands and swamps.
In 1852, Charles Ellet Jr., a civil engineer became a vocal critic of the Missouri Levee system. Ellet predicted the fate of Missouri flooding which we see today, as more levees cause flooding than serve as protection. Ellet focused specifically on the flooding of the Upper Mississippi Delta in Missouri. Ellet explained that rivers without levees naturally had larger widths and were able to spread farther when flooding happened, causing a more even flood. The levee, however, causes the river to narrow and confines it. Thus when rain events occur, especially extreme rain events, the river is restricted and rises higher and flows faster. Levees cause the slope and velocity of the river to increase, so water from uplands are brought down more rapidly and the land downstream floods more rapidly because of it. Ellis even wrote that relying on levees “encourages a false security.”

As the development of levees and communities continued across the country, floodplains were devastated but continued to flood. Several particularly large floods in the early 20th century led to Congress passing the Flood Control Act of 1917. The act provided additional funding to the construction of levees.

In 1936, major flooding during the Great Depression brought devastation to the Midwest. With few resources to prevent and respond to flooding, congress passed the Flood Control Act of 1936. In the years following this act, the Army Corps of Engineers constructed hundreds of more levees.


93 Ibid., p.9.

The Levees Today

In Missouri today, there are 318 levee systems, totaling 2,042 miles. The 318 levee systems consist of 1,777 levee structures that have an average age of 64 years. Levees are maintained and supervised by county levee districts and the U.S. Army Corps of Engineers. The Clean Water Act and the granting of supervision of navigable waters to the Army Corps of Engineers has made levee collaboration extremely difficult. Collaboration is difficult due to the slowness of the federal system. It is nearly impossible for communities and landowners to receive federal funding for a levee.

Counties with the tax money to invest in levees often do, while towns with smaller populations or low income populations are left in the dust, or mud, if you will. Following the 2019 flooding, 850 miles worth of levees in Missouri are in need of repair, totaling $1.15 billion in repair costs. These levees alone account for about 40% of the levees in the state.

An example of negative interactions between the levee system and low income populations would be the city of Eureka, Missouri, located Southwest of St. Louis. In December 2015, a large storm brought 10 inches of rain in the city. The city is bordered by the Meramec River. The water in the Meramec rose, but this was not the only reason that the city was devastated by flooding. 12 miles upstream from Eureka is a wealthier city, Valley Park. Valley Park has more resources than Eureka and was able to invest town funds into a three mile levee along the Meramec River.

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95 National Levee Database. Retrieved From: https://levees.sec.usace.army.mil/#/
As the levee protected Valley Park, it devastated Eureka and surrounding towns downstream. Levees can be successful in protecting certain areas as long as the levee is not topped with water, but make the problem much worse downstream. Although this is an example of how levees impact residential properties, the impact of levees are the same on agricultural properties as well.

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Chapter 6: Jackson County Case Study

Farming Case Study: Levasy, Missouri (Eastern Jackson County)

Large communities impacted by levee failures have received media attention, yet little research has been conducted on flooding events in Jackson County, Missouri. This section aims to explore the impacts of the broken levees on landowners, farmlands, and farm production.

What makes Jackson County, specifically Levasy, a city within the county particularly interesting, is that it is a small farming community that was impacted greatly by 2019 flooding. Jackson County has 706 farms, with an average farm size of 150 acres. Jackson County has 386,560 acres, and of that land, 105,954 acres is farmland, meaning that roughly 1/3 of the county is farmland. It is also a representative mix of both upland and floodplain farming.

Fig 14, Jackson County, MO, Credit: Benée Hershon

Jackson County Agricultural Production at a Glance

The majority of the farms in the county are mainly used for beef cattle production. In 2019, the USDA estimated that the county produced 11,800 cattle and calves. USDA data shows a decline in cattle and calves in Jackson County, this decline in 2019 may be influenced by flooding events.

![Jackson County USDA Cattle Estimates](image)

*Fig 15, USDA Cattle by County Data, Source: Benée Hershon*  

The county also produces large amounts of corn, soy and wheat crops. In 2017, 3,308,425 bushels of corn for grain was produced. Soy is also a large crop produced in the county, with 1,508, 150 bushels produced in 2017. Additionally, in 2017, 124, 812 bushels of wheat for grain was produced.

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100 Ibid.
Additionally, 2017 USDA census data found that only 10 farms in Jackson County practiced alley cropping, silvopasture, forest farming, or had riparian forest buffers or windbreaks. These measures can be crucial in reducing soil erosion. 68 farms practiced rotational grazing or management intensive grazing in 2017, while in 2012, 81 did. 21 farms in 2017 were either USDA organic certified or followed organic standards without certification.

![Fig 16, USDA Census Drainage Data, Source: Benée Hershon](https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Levels/Missouri/st29_2_0043_0043.pdf)

2017 USDA census data also found that 42 farms were drained by tile, while 97 farms were artificially drained by ditches. The increase in ditching from 2012 can be attributed to flood

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mitigation efforts by the Jackson County Soil and Water District, which has been actively promoting ditching to farmers.\textsuperscript{104} Both tile drainage and ditch drainage are a form of agricultural water management. Excess water can impact soil and crops negatively. Excess water can impact root development, soil degradation and compaction, and overall crop growth. Too much water on soil can also impact farm machinery, as excess water creates muddy conditions.

Tile drainage attempts to solve these problems. Tile drainage removes water from the subsurface of the soil. Excess water from the soil is removed through PVC drainage pipes, referred to as tile.\textsuperscript{105} These tiles are installed below the soil, under the root zone.\textsuperscript{106} Ditch drainage also attempts to solve the same problems as tile drainage, although through surface water control. A ditch is an artificial depression created to drain surface water from fields. Drainage results in the lowering of the water table.\textsuperscript{107} Both practices are frequently used together to control water on agricultural lands and are a crucial aspect of flood management practices today. The issue in this common practice is that as water drains out of a field, it flows more rapidly into waterways downstream. In other words, one farm’s solution becomes another farm’s problem.

\textsuperscript{104} This information was gathered for my interview with the Soil and Water Conservation District’s District Conservationist.
\textsuperscript{105} That's because before there was PVC material, there was tile.
123 farms in 2017 reported that an average of 204 acres per farm practiced no-tillage practices, while 51 farms reported that an average of 376 acres per farm practiced reduced tillage. The total acreage of no-tillage in Jackson County was 25,146 and the total acreage of reduced tillage was 19,190 compared to 23,420 and 17,309 respectively in 2012.

37 farms reported that an average of 223 acres per farm were intensively tilled. Only 29 farms reported using cover crops, with an average of 61 acres per farm covered. No-tillage is valuable for healthy soils as it retains the nutrients of the soil and minimizes erosion. One large downside to no-tillage, is an increased use of herbicide, as tillage uproots weeds.
Compared to 2012 USDA census data, farms in Jackson County are increasing sustainable agricultural practices, such as reduction of tillage and use of cover crops, although these changes are being slowly adapted and met with resistance.

**Jackson County 2019 Flooding Damage**

Although a large portion of flooding damage across the state occurred in March 2019, May 2019 also had unprecedented rainfall which furthered the damage of the March floods. Jackson County, Missouri, located along the Missouri river was particularly hit hard by the 2019 flooding events.

Flood water across the county reached historic levels which passed 1993 levels. The city of Levasy was impacted the most by the flooding. Floodwaters reached highway 24 making it impassable. It is estimated that 2,800 acres of residential and commercial property were impacted by floodwaters.

The flooding in this region specifically impacted low-income families. The average household income of Jackson County is $45,796. In Missouri, households with an income of $48,678 or less are referred to as low income.

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10 Missouri Census Data Center. “MCDC Demographic Profile”. Retrieved From: http://mcdc.missouri.edu/cgi-bin/broker?_PROGRAM=apps.dp3_2k.sas&st=29&co=095

Flooding in the county began in March 2019 due to historically high rainfall events. This flooding damaged soil, crops, rangeland, and some residential property.

The worst of the flooding occurred in June 2019. On Saturday, June 1, 2019, one of the county’s levees was breached due to a combination of local rainfall and an overall rise of the Missouri River due to statewide rainfall. The levee was located on 2121 Diekman Road in Sibley, Missouri. The levee was located on the property of the Serenity Ranch, a ranch and horseback riding facility that provides equine therapy. The property was flooded just days before owner, Clint Nimmo could sell it at auction.

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During the first day of flooding, local newspaper, *The Kansas City Star* interviewed farmer Randy Stock who owns a farm north of Levasy:

This spring the big culprit is it's just been raining, it rains and dries up a couple days and then rains several more… typically at 23 feet is where we start to worry about flooding, it’s at 28 something today. We were about four inches from holding it all and we were doing all the work we could. Bulldozing, building barricades and trying to kinda plug the dike, if you will. And then yesterday it popped loose in one spot. It was only four foot wide. And that little four foot wide spot resulted in everything you see [flooding] back here.\(^\text{115}\)

A combination of extreme rainfall and a broken levee devastated the county. The four foot wide gap in the levee caused the water to narrow and flow even faster.

On Sunday, June 2, 2019 a second of the county’s levees was breached. The levee was located by Highway 24 on the South side of Levasy, Missouri. The two levees which were breached were both located directly behind residential properties.\(^\text{116}\)

### Flooding Impacts on Agriculture in Jackson County

USDA census results reveal that the 2019 season was greatly impacted by flooding events in Jackson County. In comparison to the 2018 season, corn production fell by 26%.\(^\text{117}\)

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As flood waters spread throughout the county, corn crops were ruined and corn could not be planted. In comparison to the 2018 planting season, the amount of acres planted fell by 17%.

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The corn crop was perhaps the most impacted by the flooding in Jackson County. Soy production fell by 5% and beef cattle production fell by 2% in comparison to production in 2018.

Response to Flooding in Jackson County

Jackson County received local and statewide news coverage during and after the flooding events. The county received little national coverage, as did many other small farming communities throughout Missouri.

As a result of flooding, Missouri Governor Mike Parson, requested a federal disaster declaration. Preliminary damage assessments began on June 12, 2018. These assessments were conducted by FEMA, the U.S. Small Business Administration, the Missouri State Emergency Management Agency and local emergency management officials.120

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President Trump responded to the flooding through a major disaster declaration covering several countries across Missouri. Under this declaration, Jackson County was designated as a primary county that had access to priority funding. The declaration allowed business owners and homeowners to apply for grants up to $2 million and $200,000 respectively.  

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122 Ibid.
Chapter 7: The Great Flood Management Debate

Flood Management Debates in Jackson County, MO

Through performing a stakeholder analysis and several interviews of key players in Jackson County, I found that one side of stakeholders wishes to let the floodplain serve as a floodplain and end costly investments to the levee system. This side of the debate is mainly comprised of residential property owners, insurance agents, and conservationists.

Another side wishes to continue to repair the levee system and invest in sustainable agriculture. This side of the debate is a diverse group of stakeholders and is composed of residential property owners who see the levee as a valuable protection system, farmers, and conservationists who want to support farmers and sustainable agriculture. This section aims to explore all sides of this complex debate and will integrate information from interviews of key stakeholders of both sides.

Interview Process, Methods and Analysis

To retrieve information regarding both sides of this debate, I conducted interviews with relevant key players of Jackson County (n=5). Questions asked differed based on the role and profession of the individual in the community. Common questions included:

- What is your role in the community of Jackson County?
- What was your experience during the 2019 flood? Was your property damaged?
- Do you reside by a levee?
- How have you responded to the issue of flooding?
- How do you think flood management should be handled in Jackson County?
● What is your experience in agriculture or with the agricultural community?

● How do you manage your land? What sustainability measure do you implement?

If you do not manage land, do you have an opinion on how agricultural properties should be managed?

● What are your thoughts on the river debate? Should we continue to develop the floodplain?

Interviews ranged from twenty minutes to forty minutes in length and typically began with conversations prior to the interview. These conversations created an opportunity to understand the individual's background and gain rapport. Additionally, I provided a brief summary of my research and gave an opportunity for the participant to ask any questions. Prior to beginning the interview, I again asked for consent in recording the interviews and taking notes.

The length of interviews allowed for a unique opportunity to truly understand the individual’s role within the community, their experience with flooding, and what they believe should be done in terms of flood management. It was important to truly understand the complex emotions of the individuals, as their livelihoods and families are tied both to agriculture and flooding. Choosing to analyze experience and self-reflection through a narrative analysis allowed me to understand the complicated role that flooding has on each individual. Furthermore, a small sample size did not require extensive coding of qualitative data. Interviews were transcribed and analyzed for commonalities. Commonalities that were found sorted participants into either side of the flood management debate. Many participants had statements which aligned with one side

123 In correspondence, I informed participants that interviews would be twenty minutes at most. Participants were extremely willing to share their experiences and all interviews exceeded this original projection.
of the debate, while also understanding and sympathizing with the other side of the debate. Although only two sides are highlighted, these sides have much crossover of opinions.

**Recruitment and Sample Population**

After receiving approval from Brandeis University Institutional Review Board (IRB)\textsuperscript{124} at the end of January 2020, I began contacting extension agents in February 2020 through email and phone calls. The sample for this study was recruited through University of Missouri Extension. After connecting and speaking with several extension agents assigned to Jackson County at University of Missouri Extension, extension agents contacted farmers and other relevant individuals who they have worked with, and asked if they would be interested in participating in my research. The extension agent would then connect us through email, and I then emailed more information regarding my research and a consent form. All participants were briefed on this research verbally through extension agents, and through emails I sent prior to speaking over the phone.

After receiving contact information for several farmers and relevant stakeholders, I conducted interviews throughout March 2020.

<table>
<thead>
<tr>
<th>Participant #</th>
<th>Self-Identified Role</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Farmer</td>
</tr>
<tr>
<td>2</td>
<td>Farmer</td>
</tr>
<tr>
<td>3</td>
<td>Insurance Agent and Farmer</td>
</tr>
<tr>
<td>4</td>
<td>Soil and Water District Conservationist</td>
</tr>
</tbody>
</table>

\textsuperscript{124} See appendices for recruitment emails, interview guides and consent form
The group of respondents was composed only of men, who all have lived in Jackson County for over ten years. All have had current and previous experience in agriculture and a familial connection to the agricultural industry.

**Limitations**

Limitations of this research include the number of participants. The participants of this research only represent a small portion of the agricultural community of Jackson County. Due to the small number of participants, this research is not fully representative of all of the opinions of this complex flood management debate.

If I were to continue this research, I would contact extension agents from other universities that service Jackson County, who may be able to connect me with more farmers from the community. Due to the sensitivity of the situation, it was difficult to obtain interviews with farmers from Levasy who had been impacted by flooding in the county the most. All participants interviewed had experience with flooding, but none had to evacuate and sell their land due to damage, such as the farmers in Levasy.

Future research could interview this population and also interview relevant governmental organizations such as FEMA and the U.S. Army Corps of Engineers. It would be interesting to interview federal stakeholders and could aid in truly understanding all sides of the flood management debate.
Literature Review

Under the National Flood Insurance Program, Levasy, MO is classified as a parcel that is both protected by flooding due to levees, but also prone to flooding due to levees. The levees ultimately led to the demise of Levasy, so how can they protect the land?

Fig 22, FEMA Flood Risk in Jackson County, MO, Source: FEMA

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Literature also explores this debate of whether levees truly protect communities or if we should simply “let the river be the river” and allow the floodplain to naturally flood. Two studies have found that levees are a financial drain on communities, and the success of levees is dependent on constant maintenance. A 2016 study by Pinter modeled flood risk behind levees. Levees have the potential to be successful in protecting land, specifically residential and agricultural lands. Successful levee protection can be achieved with constant upkeep. According to the study, under extreme rainfall events, the levee can create high flood surcharges. Surcharges can average 1.2-1.5 meters high. If the levee is in good condition, it will sustain this surcharge. If the levee is not in good condition, it will not sustain the surcharge. In most cases of 2019 flooding, the levees were not in good condition and could not sustain the surcharges. The study cited the cost of flood damage per year to be $562,500 per community. In short, levees are only successful when they do not fail, which requires constant funding and upkeep. Levees are a large investment with little financial reward.126

A 2012 study by Heine drew similar conclusions. The study used stream gauge records to assess the impact of levees on flood levels. Levees were studied in several states and had different stream sizes, levee sizes and degrees of floodplain constriction but the results told a consistent story. At all sites the levees provided little protection, and in cases of levee failure, the levee heightened damage. In other words, the levee had no preventative impact.127

On the other side of the debate, some see the potential for sustainable agriculture and the levee system to work symbiotically. A 2009 study by Olson, assessing the impacts of the 2008

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flooding in Missouri, found that flooding events caused a delay in planting followed by an increase in planting to keep up with production. This intensive planting caused further damage to the soil and erosion. The study suggests regenerative farming practices to reduce future flooding on agricultural lands but also suggests further investments into the levee system.\(^{128}\)

This view is a similar view to conservation agencies in the region such as the USDA, Farm Service Agency (FSA), Emergency Conservation Program (ECP), Natural Resources Conservation Service (NRCS), and Soil and Water Conservation Districts (SWCDs).

This debate is not only present in research and academia, but within the Jackson County agricultural community itself. The next section aims to explore this debate through interviews with key players.

**Side 1 Interviews: Let the River be the River**

In the debate of flood management of the Missouri River, an alternative approach which arises is “let the river be the river,” and naturally flood without a levee. This side of the debate is rooted in the idea that farmers should not be farming in the floodplain at all, and the levee system is not sufficient protection from flooding. The river should be able to spread across the floodplain during flooding events, and agricultural properties prevent that from happening.

Professor J. David Rogers is a professor of Geological Engineering at the University of Missouri. He argues that the levee system is fatally flawed and causes more damage than

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benefits. Rogers states, “You can’t control the river forever.” Without constant repairs, the levee system will not provide sufficient protection.

An insurance agent of Jackson County echoes this same view. In our interview, he stated, “I don't know that we can absolutely control nature...water always wins.” As an insurance agent, he offers a unique view, as he works with both agricultural and residential properties. He states that the problem is not just agricultural properties. It is also development in the floodplain: “Naturally that [flooding] would have probably absorbed in the soil, but now due to development or large areas of asphalt and concrete, I think that that probably has changed flows.”

Due to recent flooding events, he has noticed that more people are investing in private flood insurance outside of those required to purchase insurance due to requirements of FEMA’s National Flood Insurance Program. He shared that even though most farmers in the floodplain are encouraged to purchase flood insurance, many who lost their properties in Jackson County due to 2019 flooding did not have any insurance. He notes that these homes are currently being bought, renovated, and re-sold, while farmers and landowners have had to move and find new homes and land outside of the county. Additionally, he expressed concern for the future property owners who purchase these renovated homes. He notes that those who purchase the land may not be aware of the degree of flooding which took place, and may purchase these properties due to their lower sales prices. He fears that the cycle will simply continue with these properties being flooded out, residents being evacuated, and draining government funding into what he believes may be a lost cause.

Similar to the insurance agent, the district conservationist notes the cyclical nature of these floods. Following flooding, he was responsible for visiting farms and performing damage assessment surveys. Our interview took place on March 13, 2020 and he stated, “...probably two weeks ago, I think we just finally finished the last survey in Jackson County that we needed to accomplish.” The severe flooding events occurred in early June 2019 and the damage assessment surveys took months to complete. He notes that the assessment surveys take a large amount of time and funding. Just as the assessment surveys were finished, the farming season has started again. He notes that many properties are still dealing with debris and sand from last year, he states:

Even now, it started to rain again, we're getting back into spring here. So, unfortunately, it's looking like some of it's probably not going to get cleared off again. And there's a good possibility that several hundred acres just in Jackson County here could be basically useless for this year again. So that's kind of the problem that we've been dealing with, is it's gonna be tough at any point to get out there and get that stuff done. So it's kind of back and forth. But here we are a year later and we're still fighting that fight even now.

The impacts of flooding are still present in the county and a year later, flooding from last year is still impacting the planting season. Every new season brings the possibility of flooding and could again continue the cycle of damage and repair.

A farmer in Jackson County, who was minimally impacted by the flooding notes that other farmers he knows are still dealing with debris He notes, “It takes a large toll to go back each year and deal with these floods… some seasons are worse than others and you don’t always know what you’re gonna get.” In speaking with him, it is clear that flooding not only takes a toll on the land, but the cycle of constant damage and repair takes a mental health toll on farmers as well. He stressed that the impacts of flooding are always present, “It's interesting how in today’s society, we are all in shock and awe and it's talked about when it [flooding] happens, but there's
so much in the world that has quickly died off in conversation now… these issues are still here”. Although media coverage of the flooding damage to Levasy and Jackson County only occurred in June, these issues do not simply go away overnight.

Even with damage still present throughout the county, specifically in Levasy, the levees have been repaired since last spring. The Jackson County Soil and Water District conservationist states that a great deal of the levees which caused damage were privately owned, although the Army Corps of Engineers-maintained levees are the ones that receive the most backlash from the community.

The district conservationist attributes this backlash to skepticism of outsiders and community members wanting something to blame. He notes that community members are not blaming farmers, but they are blaming the levees. He states that the private levee owners have “...tried to build them up a little bit more than they had before.” Despite these efforts, the risk of private levees is large, he states, “Most of those [levees] aren’t Corps maintained. They are almost all privately owned, which means the weakest point is where it all starts. So, even if one of them is not up to snuff, it could cause a lot of problems for everybody else.”

Although the district conservationist wishes to support farmers, he notes that the levees do not guarantee protection, especially taking into account their private ownership and maintenance.

In speaking with the participants, it is clear that they acknowledge the lack of support which levees provide. They see levees as a temporary solution, one which will eventually cause damage down the line. These participants acknowledge that the river cannot be controlled forever, but do not explicitly state that farmers should leave the floodplain. With all of the
participants being connected to the agricultural community through their livelihoods and family, it is unlikely that they wish for farmers to leave. Participants expressed great respect for the farmers of their community, but also expressed sympathy and a desire to revert this cycle of damage.

**Side 2 Interviews: Invest in Levees and Sustainable Agriculture**

In flood management, another side is in favor of maintaining investments and repairs to the levee system. This side views the levees as a valuable resource for protection of farmlands and communities in the floodplain. Additionally, conservationists on this side of the debate argue that a collaboration between levees and sustainable agricultural practices could be a solution to flood management.

A long-time resident of Jackson County, who lived through both the 1993 and 2019 floods, and comes from a farming family said:

I can honestly say that I don't believe they would relocate because the farmland itself has been in their family for many generations. Therefore, they're not just producing because it's land to produce. It's because it's a tradition and their heritage, and their family. So, therefore, I don't think they would relocate even if they had better or more flat land, so to speak, that they didn't want because they're believing that that asset is part of their family.

Although the FEMA buyback program and even eminent domain could be solutions to moving farmers and development out of the flood plain, Missouri is a state which holds the family farm close to its heart. In Missouri, farming is not just about business. Farming is about family tradition. The Soil and Water District conservationist of Jackson County echoed these sentiments, “I know those guys that farm down there would never give up their ground unless it was literally pried away from them.”
The district conservationist continued to say that the farming which occurs in the floodplain is some of the most productive agriculture in the region. Taking that resource away could pose a threat to the local food system and food insecure communities in the region.

Removing farms from the floodplain could potentially impact local food systems, but flooding on these farms can also do this by causing a delay in planting. The district conservationist noted that flooding not only caused delays in the planting season, but left sand and debris on farmlands and drainage ditches.

The district conservationist notes that sustainable agriculture could help with reducing impacts of flooding, but the levees are still necessary for flood protection. Promoting sustainable agriculture in Jackson County has been of one the Soil and Water Conservation District’s biggest challenge, the district conservationist states:

...there's an old method of thinking how to farm, that you got to till everything that you can't plant anything directly into another crop. You got to work the soil because that's the only way that anything will ever grow in it. And, you know, the science behind it has basically proven that that's not true at all.

The Soil and Water Conservation District has a USDA funded cover crop program encouraging farmers to plant winter cover crops to maintain healthy soil biology and stability. He states:

Some people have been really forward and gotten on board pretty quickly. But a lot of people are extremely, extremely against it. Part of that is one of the main arguments is that it costs too much money, or that it takes too much time or something along those lines. But what we've also found is that by maintaining those cover crops, it actually not only will improve your productivity, but it can also help to protect against things like that flood that we were talking about. So when soil gets worked up heavily when it has very poor microbiome and an aggregate component of it, the part that helps keep it together really starts to fall down. So what will happen is when you get water, a lot of water or heavy rain, it will just literally wash away. If we can maintain the aggregate component of it more, it'll stick together better. So when you get things like heavy rains, or floods or anything like that, there's a greater chance that it will basically stick together.
The District Conservationist believes that successful flood mitigation will result in implementing these practices on farms up-stream from the floodplain and within the floodplain. Implementing sustainable soil practices will lessen runoff upstream and create soil resilience within the floodplain during flooding events. Cover crops have been shown to make an impact in the resiliency of the soil, although concerns of investing into a new practice has been met with hesitation. The district conservationist states:

We’ve shown countless times the amount of benefit that these cover crops could have. And you know, it's not a cure all by any means, but it certainly has a positive effect is what we've found. But they're just many, many farmers that are unwilling to kind of switch over to that, unfortunately. But, you know, that's their private land.

Although many farmers in Jackson County have been actively against trying sustainable agricultural practices, the district conservationist finds hope in the new and younger generation of farmers, “I think it'll continue to improve as more people are open and willing to listen to those ideas.” As more farmers begin to adopt sustainable practices, such as cover crop and no-till practices that the Soil and Water Conservation District is promoting, perhaps the impacts of flooding may be lessened.

A rancher of a cattle operation in Jackson County shared which sustainable measures he has adopted on his property, he states:

We’ve adopted a strict rotational grazing schedule on our property. On our grassland, we try to promote as much rotational grazing as we can… we are just trying to get as much use out of the land and still practicing good conservation at the same time.

It was clear in our conversation that he takes a lot of pride in taking care of his land. He sees rotational grazing as not only a sustainability measure, but a crucial step for successful and
healthy land. He expressed that he has provided advice on sustainable grazing to fellow farmers. Perhaps the keys to successful sustainability are the informational networks between farmers in the industry, but he also finds much hope in county conservation programs.

When asked his thoughts on sustainable agriculture throughout the industry he stated:

I think as an industry, we're getting better all the time. We have a lot of erosion in the Midwest in Missouri… the tax money going into conservation programs, that money's gone to build lots and lots of terraces and Water Conservation structures and those kinds of things. The best of those dollars are being invested in our farm lands and the conservation programs help us be better stewards of the soil.

It is interesting how the district conservationist and rancher have different views on sustainability among farmers. It seems that sustainability is being slowly adopted with the help of conservation programs. To express that an older generation of farmers is entirely against sustainability is not true according to this fifth generation rancher. It is clear that farmers are extremely invested in their lands, and removing farmers from the floodplain is unrealistic to these participants. Sustainable measures that come both from farmers and local conservation organizations hold promise to these participants and could be a solution to flood management.
Chapter 8: Sustainable Agriculture as a Flood Management Strategy

Flood Management Solutions: Sustainable Agriculture

Sustainable agriculture is agriculture that produces food without depleting resources and polluting the environment. Sustainable agriculture is guided by a set of principles which encompasses all aspects of agriculture, from the health of the soil to those who work it.

In order for sustainable agriculture to be successful, specific physical practices must be altered, but so must social values. The success of sustainable agriculture is dependent on socially just labor and agricultural systems.

Sustainable agriculture requires farmers to re-evaluate the entirety of their business. Sustainable agriculture can be seen through three lenses: economic sustainability, social sustainability, and environmental sustainability.

Economic sustainability

Economic sustainability success can be measured as debt goes down. Farming is a unique business as it is tied closely to the personal lives of farmers. Family savings or net worth consistently increasing is a mark of economic sustainability.

Family debt decreasing is crucial to sustainability. Profits from the farm itself should be consistently profitable from year to year, and as sustainable measures are implemented, the purchase of off-farm feed and fertilizer should decrease as resources from the farm itself are

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utilized. Economic sustainability is also determined by a decrease in reliance on government loans and funding.\footnote{Earles, R., & Williams, P. (2005). Sustainable Agriculture: An Introduction. \textit{Appropriate Technology Transfer for Rural Areas (ATTRA)}, 8.}

In vegetable operations, the community supported agriculture (CSA) model has been shown to be successful for economic sustainability. Community members purchase different levels of shares at the beginning of the growing season and pick up produce on a weekly basis throughout the season. Funds which are collected at the beginning of the season are used for seed purchases and other necessities to ensure success for the season. It is important to note that a CSA model is typically only realistic for small family and community farms, not commodity farms. Other economically sustainable ventures for corn and soybean growers can include agro-tourism, selling to local restaurants or institutions, and receiving an organic certification. These measures gauge community support in a way which is different, but equally as impactful as the CSA model. These ventures may not be an option for all commodity farmers.

\textbf{Social Sustainability}

Social sustainability is crucial to both the economic and environmental success of a farm and its community. Rural areas of the country are facing a crisis of “rural flight”.
Rural flight often occurs in a region due to the industrialization of agriculture. As fewer people and more machines are needed in the agriculture industry, demand for rural jobs declines. As populations in rural areas decrease due to a loss of jobs, other services and industries in that area decline as well. In short, rural flight can be attributed to job opportunity, school choice, and lack of medical services in rural communities. As rural areas become less attractive to a younger generation, rural areas have seen a decrease in their populations, while urban areas have seen an increase.

There are many definitions and ranges that determine a rural county. The USDA Census definition of a rural county is one with a population under 50,000 people. Following this

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definition, the 2000 USDA rural census of Missouri considered 4.1 million people as part of the rural population. The total state population of Missouri in 2000 was 5.6 million people, this means that 73.21% of the state population is rural.\(^\text{134}\)

![USDA Rural and Urban Counties](https://www.ers.usda.gov/webdocs/DataFiles/53180/25580_MO.pdf?v=0)

**Fig 25, USDA Rural and Urban Counties, Source: USDA Missouri\(^\text{135}\)**

It is important to note that Jackson County is considered by the USDA as half rural and half urban. Farming communities are found in the rural half of the county. During the 2019 flooding, only the rural area of the county was heavily impacted, while the urbanized area was left seemingly untouched. The urban section of the county includes Kansas City. Having a larger


\(^{135}\text{Ibid.}\)
population and more access to tax funding due to this population allows for more investment in levee infrastructure.

Social sustainability is the key to success in rural areas that have suffered the impacts of rural flight, including Jackson County. Indicators of social sustainability include that the farm supports other businesses and families in the community, profit circulates within the local economy, the number of rural families increases or remains stable, young people take over their family farm rather than move to urban counties, and college graduates return to the community after graduation.  

Although the indicators of social sustainability may appear to be lofty goals, sustainable farming truly holds a promising future. If rural farming communities can lock in their populations through sustainable business, these communities have the potential to thrive and encourage the younger generation of the community to stay. According to the 2017 USDA Census of Agriculture, there were over 321,000 young farmers under the age of 35 in the U.S. in comparison to 208,000 in 2012. This is only the second time over the past century that the number of farmers under 35 has increased.

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Environmental Sustainability

Environmental sustainability is the most crucial aspect of sustainability for flood prevention. In environmental sustainability, the farm is seen as an ecosystem. Indicators of environmental sustainability include no bare ground on the farm, clean water in farm’s ditches and streams, wildlife is abundant, and the farm landscape is diverse in vegetation.

Key steps to building towards environmental sustainability and healthy soils include using cover crops, minimizing tillage, diversifying crops, and adopting rotational grazing practices.

Jackson County’s main agricultural commodity is cattle. Although cattle have a bad reputation for methane emissions and poor soil quality, when managed correctly, cattle raising can be extremely valuable to sustainable agriculture.

A good rotational grazing schedule allows grass enough time to grow in between grazing. As cattle feed on grass, they produce manure. The relationship between cattle and soil can be incredibly sustainable and ecologically mutualistic, when feed is rich in nutrients. Forage management is a key to success. One example of a nitrogen-rich, leguminous feed is clover and alfalfa.\(^{139}\) The cattle benefit from healthy grass, while the soil benefits from nutrient-rich manure. Cattle which graze on a mixed legume pasture show an improvement in average daily weight

gains, as compared to monoculture grass. In turn, the soil will be able to capture carbon as soil mass builds and this can serve as a powerful tool for climate change mitigation.

Jackson County’s second agricultural commodity is corn. Although the agriculture within Jackson County is not completely monoculture, it is typically a rotation between corn and soybeans, these intensive practices pose many threats. Corn monoculture farming is a threat to public health, soil health, and the farmer. Corn requires a great deal of water and fertilizer, which is why runoff causes issues from stream pollution to the dead zone in the Gulf of Mexico. Pollution from runoff poses a serious threat to the health of water and the public. Monoculture farming also requires heavy use of insecticides, herbicides, and bactericides to prevent blight and disease due to a lack of diversity in what is planted on the farm. These chemicals will also ultimately end up in streams through runoff. It is important to note that herbicides are heavily used in no-till systems as well, but incorporating buffers in these systems can also prevent runoff.

The intensive farming of corn is bad for soil health as the planting of one crop can lead to harmful bacteria and blight. An example of this is the corn blight epidemic in 1970 which ruined 15% of corn crops in North America. This blight was able to cause the harm it did due a high percentage of the crop being grown at a same high yield variety.

Corn requires nitrogen but is not a nitrogen-fixing plant. As previously mentioned, fertilizer will be needed to sustain intensive corn production. In permaculture farming, where

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crops are diverse, nitrogen fixing plants such as legumes can be companion planted by corn to substitute or minimize the need for chemical fertilizers.

Other sustainable measures which can be adopted for commodity farms can include incorporating more pasture for livestock and using less grain. In livestock operations, it is crucial that farmers utilize the manure of their cattle, and spread it throughout the pasture. Using legumes as a cover crop can be a form of fertilizer as mentioned previously, but can also be used for feed instead of grain.

On monoculture commodity farms where diversifying crops may not be an option, it is crucial that farmers implement riparian buffers, terracing practices, and raised beds. Contouring farmscapes, following the contours of slopes on fields, prevents flooding in rows and soil erosion. Contouring also allows for runoff to be captured by riparian buffers or native grass strips. It is important to note that diversifying crops is a difficult option as corn and soybean farmers make long-term investments in equipment and often plant every acre possible to generate income. In 2010, equipment for corn production in the region cost $81.22 per planted acre and equipment for soy cost $73.90 per planted acre. This cost does not include insurance, repairs, or fuel.\footnote{Meade, Birgit et al. (2016). Corn and Soybean Production Costs and Export Competitiveness in Argentina, Brazil, and the United States. \textit{United States Department of Agriculture Economic Research Service. Pp.23, 46. Retrieved From:} \url{https://www.ers.usda.gov/webdocs/publications/44087/59672_eib-154_errata.pdf?v=0}} Minimizing runoff and flooding through these practices benefits soil and water health, while also respecting these investments.

Lastly, monoculture farming poses a threat to the financial security of farmers. If the crop fails, there is no other option of produce to sell. Federal crop insurance is an option to safeguard farmers from this situation, but insurance is not always a guarantee of equal profits. Crop
insurance policies only cover unavoidable situations such as natural disasters, not necessarily blight which can be prevented through growing diverse crops.

**Ecological Sustainability**

As crops are diversified and companion planted to benefit each other and the soil, insecticides and other chemicals may be reduced over time. Agricultural fields can provide a unique habitat for different species of native insects and animal pollinators.

Through encouraging ecological sustainability, farms can become working landscapes which benefit the native environment. In addition to pollinators, farms can provide crucial habitat to ground nesting birds and amphibians, which are currently suffering large population declines due to human development and climate change.

Implementing environmentally sustainable practices and planting native grasses for buffers to bodies of water and for wind erosion, can create a viable agricultural ecosystem, while also protecting soil. Native warm season and cool season grasses promote native biodiversity.

The USDA Natural Resources Conservation Service offers an Environmental Quality Incentives Program (EQIP). One example of an NRCS EQIP service is the conservation corridor program. NRCS provides free fencing for farms and private lands which dedicate a portion of their land to being a conservation corridor. As previously mentioned, Jackson County’s main agricultural commodity is cattle. Free fencing through NRCS could be an attractive option for farmers in the county. A conservation corridor is a portion of land in which landowners can plant warm season grasses to promote natural pollinators. The conservation

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corridor is a small cost for a large reward of fencing, ecological biodiversity, wind buffers and riparian buffers to prevent pollution of water sources. These measures allow farmers to protect their soils and act as conservationists.

**Sustainable Agriculture: Education and Citizen Science**

Extension agents serve as an important educator and liaison of information to farmers and farming communities. Extension agents are a valuable resource for sustainable agriculture as they connect farmers to best management practices and research from land-grant universities. University of Missouri and Lincoln University serve as a resource for Jackson County farmers. Extension agents provide a multitude of services that support all elements of sustainable agriculture from nutritional services, business services, soil services, and engineering services. Extension agents can also connect farmers to important funding opportunities that allow for sustainable practices to be more accessible, such as the previously mentioned NRCS program.144

Community is a crucial component to the success of sustainable agriculture. Citizen science is a powerful tool to connect and educate communities about science.145 Citizen science is a participatory science which serves as a bridge between education, advocacy and science. Through citizen science, farmers can harness volunteer power to conduct surveys on farms. Citizen science can be used as a form of self-accountability to ensure that farmers are improving the ecological health of fields through annual indicator species counts conducted on site. Indicator species are used to monitor overall biodiversity and outcomes of management

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144 Programs. *University of Missouri Extension*. Retrieved From: https://extension2.missouri.edu/programs
practices. Examples of this type of research can be seen in the work that the Smithsonian Conservation Biology Institute’s Virginia Working Landscapes (VWL) does with citizen science volunteers and farmers.\textsuperscript{146} Citizen scientists are trained by VWL, and farmers allow counts to be done on their property under the supervision of VWL staff. Annual counts encourage sustainability and bring in volunteers from the community. Community visibility is crucial to the support and security of farms.

Outside of agroecology efforts, citizen science can be used as a tool for food security, pest control, and research. Large projects that are utilizing farmers in this type of research include Seedsavers.org and The Great Pumpkin Project. Seedsavers.org has two citizen science projects to help determine the best varieties for successful harvests.\textsuperscript{147} This is useful information for global farming networks as our population continues to rise. The Great Pumpkin Project by the Dunn Lab at North Carolina State University monitors pests on cucurbit plants, so that researchers can expand resources on pest control for farmers.\textsuperscript{148} With only a handful of relevant projects, there is currently a gap between citizen science and agriculture, although as more partnerships grow, citizen science has the potential to serve as a resource for agricultural research, agroecology efforts, food security, and education.\textsuperscript{149}


\textsuperscript{147} Citizen Science Corps (n.d.). SeedSavers. Retrieved From: https://www.seedsavers.org/citizen-science-corps


An example of a local project for farmers in Missouri, is MO DIRT: Missourians Doing Impact Research Together. The project is through the Donald Danforth Plant Science Center and funded by the National Science Foundation (NSF), and has the goal to complete a state-wide soil health survey, create soil science curriculum in schools, and provide soil health resources to farmers throughout the state.

Citizen science is a valuable resource that can be more accessible than other sciences. Although barriers to accessibility are present, such as requiring a computer, phone, and internet, most projects are free. These barriers could pose a challenge to Jackson County, where 80% of farms have access to the internet, which leaves 20% without access. MO DIRT provides a free three-hour training and free soil test kit. Projects ask farmers to perform tasks that a majority are already doing in their work, such as collecting observations and soil samples. Citizen science has great potential in the agricultural field and is a valuable tool which can foster connections between farmers, local communities, researchers, and even policy-makers.

**Sustainable Agriculture Legislation**

One method to promote sustainable agriculture in Missouri is through legislation. Although sustainable agriculture alone will not prevent flooding in the state, it will help prevent soil erosion and build up soil mass which will in turn create more resilient soil.

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An example of healthy soil legislation that is currently being created is in Massachusetts. The Massachusetts senate is currently trying to pass Bill S.2404, “An act promoting healthy soils for reducing greenhouse gases and the effects of climate change in the commonwealth.”

The bill aims to create a healthy soils fund which has three aims: to improve soil quality on land used for commercial farming, increase carbon sequestration on these lands, and to provide benefits such as erosion control and water absorption.

The proposed bill creates a large vision for Massachusetts’ soils without explaining exactly how the bill will be implemented. Although the bill has a long way to go until it lands on the governor's desk, it makes an important statement and has support from farmers throughout the commonwealth.

Missouri has a Parks, Soils, and Water Sales tax that supports soil and water conservation programs and state parks. The tax is one tenth of the one percent sales tax. Soil and water conservation programs are crucial to sustainable agriculture throughout the state and have been passed each time it has appeared on the ballot in Missouri. Although these programs provide valuable services, more can be done. Missouri had soil-related legislation in 2018 which fell through and did not successfully pass to become law. The legislation called for the removal of sales tax exemption on fertilizers and pesticides. Taxes on these commodities would become revenue for a healthy soils fund. If Missouri adopted this legislation, it would be a radical step to

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achieving sustainable agriculture. For successful legislation, this bill would require extensive education and work towards sustainable agriculture before limiting access to fertilizers and pesticides.

Implementing the principles of sustainable agriculture into commodity farming has the potential to minimize the impacts of flooding, encourage native biodiversity, community support, and education. Although sustainable agriculture has typically been applied to smaller farmers, when applied to commodities, farmers have the potential to be the greatest conservationists of their land.

**Conclusion**

In implementing sustainable agricultural practices and even legislation, landowners, community members, and wildlife will ultimately reap the rewards. Flooding is a contentious topic, it stirs emotion. Although flooding will continue to impact Jackson County, Missouri and impacts may worsen as climate change progresses, sustainable agriculture is a clear step in the right direction.

With the support of local, state, and federal agencies, farmers have the potential to access funding in order to make sustainable agriculture a reality. As flooding devastates communities such as Levasy, Missouri and populations in rural counties age out, the state will see younger farmers adopt the land. Younger farmers have the potential to bring in sustainable land practices, but this trope time and time again proves us wrong. In the history of agriculture, there is a common hope that progress in technology, education, and the ever-growing need to feed the world will bring these changes. The future of farming communities cannot be pushed aside to the next generation. Future generations will simply have to deal with the economic burden of
flooding as land is passed down. It is possible that these communities may not be desirable as flooding continues, and perhaps these small communities may revert back to the natural floodplain.

To ensure a sustainable future for rural communities, agencies must continue to encourage and create farmer to farmer sustainable knowledge networks, where farmers are able to communicate and share knowledge with each other. Agencies must also consider new communication methods that include community engagement, such as citizen science. Funding and grant-writing resources must be accessible to farmers, and perhaps a new agency must be created in order to successfully forge this connection.

Although the future of these counties cannot be fully predicted, to “let the river be the river” or to continue to farm the floodplain is ultimately the decision of private landowners, private levee owners, private levee funders, and the Army Corps of Engineers. From an ecological standpoint, reverting floodplain farm lands back to woodlands and wetlands may be ideal for wildlife, but would displace entire communities. It seems that the residents of Jackson County will continue to rebuild and renovate the levees, just as they have done after every flooding event in the last decade.

Moving forward with the realities of the community, sustainable agriculture in combination with the protection of levees is the best approach to flood mitigation and management. Building up soil must become a priority for farmers in Jackson County. Sustainable agriculture will not only help reduce the impacts of flooding on their own properties, but could also influence the impacts of flooding on residential properties located nearby. In order
to accomplish sustainable agriculture, rural counties must receive additional attention, funding, and education from local, state, and federal stakeholders.

President Franklin Roosevelt once stated, “A nation that destroys its soil destroys itself.” Change in Jackson County agricultural practices will require change in practices across the Corn Belt and United States. Further investment in land grant extension agencies, Soil and Water Conservation Districts, NRCS, and other relevant agencies will be required. Efforts must be continued in education and outreach in order to successfully connect farmers to incentivized conservation programs.

State and federal incentive policies will go a long way in implementing change in practices, but meaningful change will require social and economic sustainability throughout the entire U.S. food system. As we make change in the soil, we must make changes that support and respect the labor of those who feed our nation.
Appendices

Appendix A: Recruitment Methods

Email to Extension Agents:

Hello,

I hope this email finds you well! My name is Benée Hershon and I am a senior at Brandeis University in Waltham, Massachusetts, studying Environmental Studies with a focus in agriculture.

This year I am writing a research thesis focusing on the impacts of the 2019 flooding in Missouri. Last spring, I worked on different farms in Virginia and West Virginia. The region I was in had dealt with the difficult impacts of flooding the spring before, and I became very interested in the issues of flood management.

The farmers I was working with spoke often about the flooding in the Midwest last spring and Missouri eventually became central to that discussion due to the combination of flooding and the levee system.

I was wondering if you may be able to connect me with any farmers in Jackson County that you work with, who would be willing to talk on the phone or through email about their land management practices with me. Any information I collect will be completely confidential and their names will not be published in my research, unless they want them to be.

Thank you for taking the time out of your day to read this! Looking forward to hearing from you.

Best,
Email to Farmers/Agricultural Key Players:

Hello,

I hope this email finds you well. My name is Benée Hershon and I am a current Environmental Studies student at Brandeis University in Waltham, Massachusetts.

This year I have decided to write a senior thesis focusing on the impacts of the 2019 flooding in Missouri. Last spring, I worked on different farms in Virginia and West Virginia. The region I was in had dealt with the difficult impacts of flooding the spring before, and I became very interested in the issues of flood management.

The farmers I was working with spoke often about the flooding in the Midwest last spring and Missouri eventually became central to that discussion due to the combination of flooding and the levee system.

The title of my project is: The Farmer and the Flood: An Exploration of Flood Management in Missouri. I am interested in how the flooding impacted farmlands and am hoping to collect data on how you manage your land and the impacts flooding has had on your property.

Your extension agent gave me your name as someone who may be interested in participating in my research. If you agree to participate in my research, I would just need about 15-20 minutes of your time to either talk over the phone or through email to ask questions about your current land use practices and how flooding has impacted your property. These conversations will be recorded and transcribed, only with your consent. Your name will only be published in my work, with your consent.

If you are interested in participating or have any questions, you can respond to this email bhershon@brandeis.edu or contact me at 774-217-0816.

Thank you for your time and I am looking forward to your response!

Best,

Benée Hershon
Appendix B: Interview Guide

Questions Regarding Basic Land Use Information:
- What is the address of your property?
- How many acres is your property?
- How long have you owned your property?
- What do you produce on your farm? Livestock, vegetables, corn, etc.?
- Is your land located on or near floodplain? If near a floodplain, how far?
- Is any of your land under conservation easement?

Questions Regarding Land Use and Sustainable Agriculture Measures:
- Do you use shrub or grass buffers on your land? If so, where are these located on your property?
- What do you do for fertility management?
- Does your farm have a USDA National Organic Program certification?
- Do you have acres transitioning into USDA National Organic Program organic production? If so, how many?
- Do you practice alley cropping, silvopasture, forest farming or have riparian forest buffers or windbreaks?
- Do you practice rotational or management-intensive grazing? If so, what is your rotational schedule?
- Do you use commercial fertilizer, lime or soil conditioners? If so, how many acres of your property is treated?
- If you use fertilizer on your soil what do you use?
- Do you use organic fertilizer on your soils?

\footnote{Not all questions were asked in interviews, as not all were applicable to the participants.}
-Is your land drained artificially drained by tile, ditch or both?

-Do you use no-till practices? If so, how many rows or acres are designated no till?

-Do you use cover crops? If so, how many rows or acres do you plant cover crop?

-Do you use intensive tillage practices? If so, how many rows or acres are intensively tilled?

Cropland on which reduced tillage, excluding no-till practices were used

Questions Regarding Flooding:

-Is your property located near a levee? If so, how far is the levee from your property line?

-Is the levee near your property privately owned and managed, managed by the county levee district or the U.S. Army Corps of Engineers?

-Did the levee near your property break during the Spring 2019 flooding events?

-How has flooding impacted your land?

Appendix C: Consent Form

You are invited to participate in a research study being conducted by Benée Hershon, a senior honors thesis student at Brandeis University in Waltham, MA. The study is being conducted under the supervision of Brian Donahue, Professor of Environmental Studies at Brandeis University.

Please read this form carefully. We encourage you to ask questions if you want more information about any part of the form or the study.

If you decide to participate in this study you will be asked to sign this form. A copy of the signed form will be given to you to keep for your records – it has important information, including whom to contact if you have questions in the future.

What is this study about?
We are conducting this study because we are trying to learn more about the impacts of the 2019 flooding events on your agricultural property. We are also trying to collect data on land use, specifically on how you manage your land.

Why have we asked you to participate?
We are asking you to take part in this study because you are a landowner who works in the agricultural industry in Jackson County, Missouri.
What will you be asked to do if you participate?
If you decide to participate in this study, you will be asked to complete an interview about your land practices and the impacts of the 2019 flooding events on your land.

We would like to audiotape you during this interview. However, if you would prefer not to be audiotaped, that is okay – you may still participate in the study. We will ask for your consent to be audiotaped at the end of this form.

The interview will be a 15-20 minute process and will occur over telephone, skype or email. We will send you the question form before the interview so that you have time to compile any data needed for your answers.

Are there any possible risks to you?
You may feel uncomfortable answering some of the questions. If a certain question or topic makes you feel uncomfortable, you are free to skip the question or ask the interviewer to move on to another topic. You can also withdraw from the study completely at any time.

There is always the risk that your information could be accidentally disclosed to people not connected with this study; however, we will do our utmost to secure your information so this does not happen.

Will you benefit from participating in the study?
Through this study we will be able to use data from your interview to stimulate how different land use practices could help reduce future flooding on your property and in your community. These results will be accessible to you and may aid you in the management of your land.

Will it cost you anything to participate in the study?
The only cost to you will be your time.

Will you be compensated or receive anything for participating in the study?
You will not receive compensation for participating in the study, but will have access to information on techniques that could be implemented on your land to reduce future flooding impacts.

How will your information be kept private?
If you do not consent to having your name published, any information that is obtained in connection with this study and that can be identified with you will remain confidential to the extent permitted by law.

The audiotape of the interview will be transcribed without any information that could identify you if you do not consent to having your name published. After it is transcribed, it will be destroyed.

If you do not consent to having your name published, the list with your name on it will be stored in a locked file cabinet in the researcher’s office. The audiotapes will be stored in a
separate locked cabinet, also in the researcher’s office. The data we collect (including the transcribed interviews) will be stored electronically in a password protected encrypted file on Box.com.

If you do not consent to having your name published, when the data from the interview is reported (in publications and presentations), it will be in aggregate form – your information will not be separable from the findings as a whole. Pseudonyms will be used when reporting data from the interviews – no identifying information (name, race/ethnicity, etc.) will be used. No quotations will be used without your express permission.

**What will happen with your information once research is complete?**
Once research is complete, after three years, all data will be scrubbed from computer files. Your data will not be used for any new research without your consent.

**What if you don’t want to participate or change your mind partway through?**
Participating in this study is completely voluntary. You have the right to refuse to participate in all or a part of this study. Even if you decide to participate now, you may change your mind and withdraw from the study at any time without penalty. You may also refuse to answer specific questions at any time without penalty – simply skip them on the questionnaire or ask the interviewer to move on to another topic.

**Who can you call if you have more questions?**
If you have any questions about the research being conducted or your participation in the study, feel free to contact the researchers at 774-217-0816 or bhershon@brandeis.edu.

If you have any questions about your rights as a subject in this study, would like to speak with someone other than the researchers about concerns you have about the study, or in the event the researchers cannot be reached, please contact the Brandeis University Human Research Protection Program at 781-736-8133 or irb@brandeis.edu

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**Subject Consent**
I have read the contents of this consent form, have been encouraged to ask questions, and have received satisfactory answers to my questions. I understand that my participation is voluntary and that I may withdraw my participation at any time without penalty. I voluntarily agree to participate in this study.156

- [ ] I do  [ ] I do not give you my permission to make an audiotape of me during this study.

- [ ] I do  [ ] I do not give you my permission to share my de-identified data in a data repository.

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156 IRB approval was given to not require signatures due to the long-distance nature of the interviews.
☐ I do ☐ I do not give you my permission to use my name in this study.

Participant’s Signature____________________    Date __________________

Investigator’s Signature____________________    Date __________________

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