

**The Impact of Fertilizer Runoff and the Clean Water Act in Corn, Rice, And Soybean
Production along the Mississippi River, and their connection to the Gulf Dead Zone**



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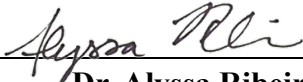
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Pledge

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Title: The Impact of Fertilizer Runoff and the Clean Water Act in Corn, Rice, And Soybean Production along the Mississippi River, and their connection to the Gulf Dead Zone

The dead zone in the Gulf of Mexico, is considered to be one of the largest in the world. One of the main leading causes is agricultural/ fertilizer runoff. A majority of the time, this pollution tends to flow in from the Mississippi River. So, in order to understand this cause of pollution, three crops that grow in three states along the Mississippi river were chosen. Corn from Iowa, Rice from Arkansas, and Soybeans from Illinois. The main objectives of this study were to see what fertilizers were being used, what role they played in the spread/creation of the dead zone, and finally, what role could the Clean Water Act(CWA) could play in addressing this problem. What these crops showed was that demand for fertilizer was high, primarily due to the fact that it helped crops grow tall and produce more yields. The most common type of fertilizer used were ones packed with nitrogen, which is one of the main chemicals found in the dead zone. Regarding the CWA, the Act mainly focuses on point source pollution and leaves nonpoint source pollution(Ag. Pollution) in the hands of the states, yet some help is offered in the form of grants. Providing this analysis and information will allow future students to recognize issues that, for some people, might not seem too urgent. Alternatively, this could give students the opportunity to look deeper into federal environmental policies and look into how policymakers decide exactly what an act will cover and what it might leave out.

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Chapter 1

History/Importance of the Gulf of Mexico

The Gulf of Mexico is where the environment and economy meet. The Gulf of Mexico is known for its “seafood markets, recreational fishing, and holiday beach destinations” (McKinney, 2021, p.31). Because of its economic importance, the Gulf helps the United States since it produces and refines much of the petroleum that we consume and export; because of this, the Gulf provides an essential link for world trade and commerce (McKinney, 2021, p.31). Since humans depend on the Gulf of Mexico, it should not come as a surprise that many human activities have altered the Gulf, and because of that, it can face many complex challenges. One of those challenges the Gulf is facing is the agricultural runoff from fertilizers that are coming down from the Mississippi River. To understand the Gulf a bit more, and specifically to understand the changes we as humans inflict on it, it is crucial to understand that the Gulf is an integrated system that responds to different drivers, pressures, stressors, and responses. Drivers can be either natural or anthropogenic forces. For example, drivers are fundamental and natural forces, and the result that may come from these drivers can force ecosystem changes in the Gulf, meaning that drivers are pushing against the resilient nature of the Gulf (McKinney et al., 2021, p.32).

On the other hand, pressures are human activities and natural processes that are a result of drivers. Natural pressures include hurricanes, nearshore current patterns, and sediment dynamics (McKinney et al., 2021, p.32). Human activities that act as pressures are focused on things such as oil and gas extraction, commercial and recreational fishing, and altered freshwater inflows (McKinney et al., 2021, p.32). An example of this could be the forced channelization of the Mississippi river. Stressors are a result of pressures. They can come from a range of either physical, chemical, or biological pressures, but they still all cause environmental effects (McKinney et al., 2021, p.32). An example of a physical stressor could be “changes in salinity and ocean acidification,” a biological stressor could be “harmful algae blooms, overfishing, or invasive species,” and a chemical stressor would be “altered nutrient inputs, and oil and chemical spills.” (McKinney et al., 2021, p.32). Finally, responses refer to humans' responses to stressors; some examples would be habitat restoration, fish management, or the release of new environmental laws. Knowing and understanding this information can allow us to

understand better and picture the role we play in the safety, health, and preservation of the Gulf of Mexico.

The Gulf's coastline comprises "half of the southern seaboard and those states are capped by the Vast Midwest"(McKinney, 2021, p.31). The Gulf annually receives about " 10.6×10^{11} m³ yr⁻¹ of freshwater via river and streamflow, of which 85 percent comes from the United States and 64 percent comes from the Mississippi River drainage alone"(Darnell & Defenbaugh, 1990, p.4). Through the Mississippi river drainage, the Gulf absorbs both the good and the bad of what flows down the U.S.'s greatest river (McKinney et al., 2021, p.31). Many things flow down the river, including pollutants like phosphorus. Another pollutant that ends up running off into the river is the nitrogen-rich fertilizers that Midwest farmers use to ensure better crop yields (Negin et al., 2020). The Mississippi river annually brings in about 4.1×10^8 metric tons of sediment, including about 3×10^9 kg of dissolved and particulate organic carbon(Darnell & Defenbaugh, 1990, p.4). Particulate organic carbon is defined "as all combustible, non-carbonate carbon that can be collected on a filter(Kharbush et al., 2020). Most of these pollutants are distributed westward on the continental shelves of Louisiana and East Texas(Darnell & Defenbaugh, 1990, p.4). Not only are agriculture fertilizer pollutants flowing down the Mississippi, but after heavy rains and melting snow, nitrogen and phosphorus from lawns or sewage treatment plants also flow into the river, ultimately ending up in the Gulf("Gulf of Mexico Dead Zone, 2020). Because of these pollutants, some parts of the Gulf of Mexico have become hypoxic dead zones (Peczynski,2013).

The Hypoxic dead zone in the Gulf of Mexico is one of the many outstanding examples of what can happen when water from inland watersheds contaminated with many nutrients reaches ocean waters (Greenhalgh & Faeth, 2001, p.976). Psychologists often use hypoxia to "describe conditions or responses produced by stressful levels of oxygen deficiency" (Rabalais et al., 2002, p. 236). At the same time, the term Dead zone refers to a period where nothing happens, and no sign of visible life can be detected in the water(Rabalais et al., 2002, p. 236). Human activity also highly influences water quality in the Gulf, but the primary cause of degraded water quality is excess nutrients (Ward,2017). As mentioned above, nitrogen and phosphorus are two primary pollutants flowing into the Mississippi and ending up in the Gulf. A

majority of the time, the pollutants are just ingredients in fertilizers that farmers use to provide their crops with all sorts of nutrients they need to grow strong and healthy (Balter,2013).

While nitrogen, phosphorus, and other nutrients are sometimes okay in small amounts, too much of them in the water can cause algae to grow faster than the ecosystem can handle. Which causes harm to the water quality, food resources, habitats, and decreases the oxygen aquatic life needs to survive (EPA, “Nutrient Pollution”). This excessive growth of algae which can cause a lack of oxygen, is called eutrophication. In 2017, the hypoxia dead zone in the Gulf was declared the largest it had ever been measured. Even if nitrogen from agriculture inputs are gone, it would take “30 years to realize the 60% decrease in load to reduce eutrophication in the Gulf” (Van Meter et al., 2018, p.427). Even though the dead zone of the Gulf of Mexico is currently centralized in one area, it does not mean that other areas are free from experiencing detrimental effects. Hypoxia can significantly damage an ecosystem causing it to crash and affect many other aquatic systems (EPA, “Nutrient Pollution”). Hypoxia can also affect an ecosystem's energy flow. Due to the lack of oxygen, “much of the system's energy is diverted from invertebrates to microbial decomposition, and the energy flows in pulses, favoring species with shorter lives”(“Eutrophication in the Gulf of Mexico,” 2012). Since longer-lived species are getting eliminated because of the lack of oxygen, there is an overall decrease in biodiversity, again impacting numerous aquatic systems, not just those that fall within the area of the hypoxic dead zone(“Eutrophication in the Gulf of Mexico,” 2012).

The Gulf of Mexico has been thrown many challenges. While the Gulf is dealing with the dead zone, there is another event in history that has also affected the Gulf, the Industrial revolution. As of 2010, there are “around 4,000 offshore oil and gas platforms, and tens of thousands miles of pipeline”(Robertson,2010), and at least half a million barrels of oil and drilling fluids have been spilled (Robertson,2010). Despite all this, little information about the Gulf was known until the BP Deepwater Horizon Spill disaster, which leaked “210 million gallons of oil and 1.8 million gallons of chemical dispersants” (Robbins et al., 2020). Large-scale spills like this can also increase the overall concentration of toxic chemicals in the affected environments (Singleton et al., 2015, p.109). Nearly ten years after the spill, scientists completed an eight-year study (2011-2018) and sampled hundreds of fish species from different locations and found evidence of oil exposure, proving that the Horizon spill disaster had lasting

effects (Kusek,2020). Because of the spill, new technology like seafloor mapping, dedicated marine mammal rehabilitation crews, policy leaders spoke out, and National Environmental Policies were created to help restore the Gulf of Mexico to pre-Deep-Water Horizon conditions. Nevertheless, a report in 2010 revealed that “66.3 million gallons of fracking waste” (Sakashita, 2021) were dumped into the Gulf over a decade. Proving just how damaging offshore fracking is to the environment. Deepwater Horizon was a tragic incident that altered the landscape of the Gulf of Mexico; still, this is not the only time that anthropogenic factors have impacted the Gulf. As we have read, runoff from fertilizers (agricultural runoff) is just as massive of a problem as the BP oil spill, and because of that and its environmental effects, I believe it deserves, if not more, the same amount of attention that the BP oil spill received.

Because of its national and even worldwide attention, the BP oil spill led to many changes. However, it also influenced public opinion regarding people seeing oil spills as an environmental concern that demanded attention. I mention this monumental event mainly to show that public opinion on environmental concerns can change and bring attention to specific topics. Taking a step back and looking at some of the information I have provided, it can be easy to misconstrue the information and downplay how much agricultural runoff is truly affecting the Gulf and place all the blame on oil and claim that we are already making moves to address that issue. But the truth is that by showing you just how much of a problem the Gulf is in, it might just sway public opinion in favor of combating fertilizer agriculture runoff.

Previous research has been done on agricultural pollution and its effects on the hypoxic dead zone. A majority of this research is about strategies to help limit the amount of agricultural runoff flowing into the river and causing the dead zone. However, the main takeaway of this is proof that agricultural runoff is a big enough problem that strategies need to be done to limit it. Proving the point that runoff flowing down the Mississippi River is playing a role in widening the Dead Zone. In this research, we learn that “Agricultural sources contributed to more than 70% of N(nitrous oxide) and phosphorus loads to the Gulf of Mexico via the Mississippi and Atchafalaya rivers, with loading doubled in the second half of the twentieth century due to increased runoff of fertilizers”(Faust et al., 2017). We also learn that the United States fertilizer application “has increased four-fold since 1961, from 50 to 200kg” and that various nonpoint sources of nutrients particularly runoff from fertilizers “have increased the nutrient load

discharged to freshwater and marine ecosystems, including the Gulf of Mexico”(Faust et al., 2017). In order to combat agricultural runoff, another study also came up with suggestions to limit this issue, one of them being placing ecosystems that are effective nitrogen sinks between agricultural fields, streams, and rivers(Mitsch et al., 2001). What this will do is act as a buffer and pick up excess nitrogen.

As we have noted thus far, the Gulf of Mexico has been through a lot of exploitation, and even though one of those significant events led to further research on the gulf, it does not mean that we should continue to let this exploitation happen so that maybe once we do get a handle on this situation, we could possibly learn something new, repeating the pattern that happened with the BP oil spill. The purpose of this project is to examine one of the causes of the Dead Zone in the Gulf, agricultural runoff, and to understand it more fully. I analyzed three different crops that grow along the Mississippi: corn, rice, and soybeans to determine what specific fertilizers are being used, how these specific fertilizers are furthering the expansion of the dead zone, and what does the history behind these crops and their agricultural practices look like? I also examined how the Clean Water Act of 1972(CWA) affects what flows into the river and looked at whether the CWA can help prevent further pollution. Even though a river and an Ocean are two different bodies of water, I am interested to know whether the CWA has any influence over controlling pollution that eventually leads into the ocean. However, before we can answer any of those questions, it is essential to look back to the past and understand the Mississippi River's history since it plays a significant role in polluting the Gulf.

History of the Mississippi River

Around 80 million years ago, there was a mountain chain that spanned the southern portion of the continent that blocked southbound water flows, causing most North American rivers to flow to the Western Interior Sea or north to Canada's Hudson. As time passed, a gap opened up between the mountains, allowing the river “we know as the Mississippi to flow to the Gulf of Mexico”(Klinkenberg, 2020). Scientists call that gap the Mississippi Embayment. As of 2014, there is a general consensus that the Mississippi began flowing through that gap around 70 million years ago when dinosaurs roamed the planet (Klinkenberg, 2020). Because of how long and wide the river is, it is unsurprising to learn that it played an essential role in history.

Throughout North America's history, the river has played a role in establishing trade routes for Native Americans and was used as a passageway for colonists/conquistadors to form new settlements and established border lines between states(Clark, 1963). During the colonization period of North America(1492-1763), there were many waves of movement; people were moving from north to south and west to east. Nevertheless, many people decided to settle along both sides of the Mississippi, mainly because of how fertile the land was for farming(Clark,1963). Colonists were not the first to realize how fertile this land was along the river. In fact, long before Europeans stepped foot on the New World, Native American tribes had grown maize(corn), beans, squashes, and sunflowers along the river, depending on cultural and environmental factors(Fritz,2000).

Similarly to many other things in history, the Mississippi River was also shaped by the needs of humans. With the technology that came from the industrial revolution, engineers in the 19th century began to shape the river to fit the needs of the growing civilization(Klein et al., 2014). They made the river “straighter, shorter and deeper,” allowing for “millions of tons of sediments away from floodplains, sometimes sending them far downstream into the deep recesses of the Gulf of Mexico(Klein et al., 2014, p.13). The whole point of shaping the river was to make sure it would not change and serve the purpose of the community, yet once the river was redesigned by man, it changed again. The river and its tributaries drain about 40 percent of the United States, so as the water flows downstream and grinds against its bend it is constantly remaking itself(Klein et al., 2014). While the water is flowing down the river, it is dropping off some of the sediment it has picked, but ultimately as the river approaches the Gulf, so does the remaining sediment and anything else the river might have picked up(Klein et al., 2014).

The Mississippi River Valley is divided into three subregions: the upper, central, and lower valleys (Fritz,2000). These three regions support different vegetation types and have different environmental boundaries, which means that each section of the Mississippi River Valley is unique in its own way. For example, “the Northern half of the river runs along the North American Prairies Province to the west”(Fritz,2000,p.227). On either side of the mouth of the Mississippi River, there are oak forest wooded areas on one side and deciduous forests on the other (Fritz,2000). As mentioned above, the lands along the river are extremely fertile, but one downside is that the bottomland of the river is susceptible to flooding because of the sections

widening at the bottom of the valley(Fritz,2000). While the Mississippi river was an amazing area to grow crops, it was also a prime location for animal and wild plant resources, which made this area a prime settlement location since there was access to an abundant amount of food.

The Mississippi River changed over time, and with those changes, the Mississippi faced many challenges. One of the most significant changes was that it became a huge dumping site as the United States developed into the country it is today. For starters, in early times, while people settled along the Mississippi River to farm and start a new life, they also settled there and along other rivers to have a way to dispose of waste(Dunbar,2018). For example, around the 1920s, the Twin Cities (Minnesota) sent raw sewage straight into the river. Now, the waste is sent to a wastewater treatment plant before it is sent back to the river, but with the new treated water, chemicals like phosphorus and pharmaceuticals like codeine can still slip through and can affect aquatic life(Dunbar,2018). Another big thing that used to get dumped into the river was industrial waste, especially at the beginning of the industrial revolution(Dunbar,2018). Minneapolis had a coal gasification plant that produced oil, and the leftover waste, which was full of arsenic, would get thrown into the river(Dunbar,2018). Now, industrial waste dumping is more regulated.

One of the main challenges the Mississippi river has faced, and the main reason we have to look back into the history of this river, is the problem of agricultural runoff pollution. As we have seen from the two examples above, sewage and industrial waste are pollutants that have been dumped into our waters. Yet these incidents have been addressed and are no longer happening as frequently as they did in the past. The Mississippi River is still fighting the battle of being polluted by fertilizers from agricultural runoff. While farming played a large role in the history of this river, it is essential to remember that this specific technique is not only affecting the river but also the Gulf of Mexico.

Chapter 2: Corn, Rice, and Soybeans

Now that we understand the history of the Gulf of Mexico and the Mississippi River, it is time to look into three different crops that grow along the Mississippi River. We will be looking at corn production in Iowa, rice in Arkansas, and soybeans in Illinois. With these crops, we will be looking into the history of their development in these states, the agricultural practices associated with each, and the introduction of fertilizer into their growth. Finally, I will analyze how much fertilizer goes into growing these crops and potentially how much runoff goes into the Gulf of Mexico.

History of Corn, Rice, and Soybeans

Corn in Iowa

Corn, also known as Indian Corn or Maize, is a cereal plant of the grass family and is an edible grain. The crop can be identified by its “long stalk, upper tassel, and ears of corn. The ear of corn holds the kernels and cob, surrounded by the silk, which usually helps pollinate the plant”(Sauder, 2022). This domesticated crop originated in the Americas and is one of the world's most widely distributed crops. Corn is a crop that can be grown worldwide in large quantities but is mainly produced in countries near the equator. North and Central America, West Africa, Central Asia, Brazil, and China are countries that are known to be top producers of corn. The native peoples of Mexico first domesticated corn, but it was later shared with the rest of the world due to the Columbian exchange. The Columbian Exchange was an exchange of diseases, ideas, food crops, and populations between the New World (America) and the Old World(Europe) following the 1492 voyage of Cristopher Columbus(Nunn & Qian, 2010). Since then, corn has grown to be considered one of the most important crops in the United States and is a staple food not only for humans but for animals as well. In the United States, corn is the “second-highest export, generating around 9 billion annually”(Sauder, 2022).

Iowa was opened for settlement and farming by colonists in 1833. Iowa's soil and climate were ideal for the growing conditions of corn; between 1840 and 1860, Iowa's corn production increased by 400%(Throne,1949). By 1878, Iowa led the nation in corn production, followed by Illinois and Missouri (Troyer, 2006). One main reason for this increase in production was the introduction of the railroad in the state. The railroad allowed for the faster transportation of crops

from state to state, so much so that it inspired farmers to farm more since it became easier for them to sell their crops(Zdorkowski, 2013). Agriculture in Iowa is seen as a part of their culture, so much so that “farm families have grown corn in Iowa for 150 years now, many families passing down the evolving culture of corn production from generation to generation” (Zdorkowski, 2013). From this information, we can see how important corn is to Iowa. It provides us with a view into possibly why fertilizer was used so much to support the constant growth of corn since fertilizer can help increase the yield of a crop.

Rice in Arkansas

Rice is the world’s largest food crop, providing the caloric needs for millions of people daily(Sweeney & McCouch, 2007). However, the main thing about this crop is that there are two distinct types of domesticated rice, Asian and African. In Arkansas, the main rice grown is Asian rice (*Oryza sativa*). There are many variations of this rice, but they can mostly be sorted into three distinct groups: short-grain, medium-grain, and long-grain(Norman et al., 2005). Rice was first introduced in the western hemisphere when a seed was planted in South Carolina in 1863 or 1864 (Lee,1988). It spread slowly throughout the rest of the southeastern United States. In 1896, W.H. Fuller traveled to Louisiana, where he saw rice for the first time and was inspired to bring this crop back home with him. Fuller's first few attempts at cultivating rice were unsuccessful, so he moved back to Louisiana to learn more about how this crop was grown. Once he returned, he was able to grow bushels of rice and was seen as an inspiration to other farmers in Arkansas to begin growing rice(Rosencrantz,1946). After getting into a rhythm, in the few years of the Rice Belt, farmers were flourishing and making a lot of money(Rosencrantz,1946).

In 2021, Arkansas was the leading rice producer in the United States; the state represented 47.5% of total U.S. rice production and 47.8% of the total acres planted for rice(Hardke,2021). Rice is Arkansas's third highest-value commodity and its top agricultural export; annually, this crop brings roughly \$ 1 billion to the state and accounts for around 25,000 jobs(Think Rice, n.d). Similar to how it was with corn in Iowa, rice is a huge part of Arkansas culture. It was one of the things that put their state on the map earlier. Moreover, with how much money this crop brings to the state government and how many lives would be affected if the production of this crop took a major hit, the state does everything in its power to keep the crop in total production(Think Rice, n.d). Meaning that farmers and the local and state government will

do whatever it takes to ensure this crop is growing well and producing high amounts of rice to protect the state's income and the jobs of thousands of people.

Soybeans in Illinois

The domestication of soybeans can be traced all the way back to China in the 11th century B.C. However, it was not introduced to North America until 1765 by Samuel Bowen in Savannah, Georgia, and was being grown in Philadelphia by 1804 (Hymowitz, 1987). Compared to other states in North America, soybeans arrived in Illinois rather late(Aoyagi & Shurtleff, n.d). One of the earliest introductions of soybeans to Illinois was by Dr. Benjamin Franklin Edwards in 1851(Hymowitz, 1987). He had received soybean seeds as a gift from the Japanese; once Benjamin returned home, he gave them to Mr. John H. Lea, a friend, who planted them in their garden(Hymowitz, 1987). After harvesting the soybean seeds, Lea handed them out to more and more people, causing a spread of soybeans(Hymowitz, 1987).

Another one of the earliest promoters of planting soybeans was a farmer named W.H. Stoddard from Carlinville in West Central Illinois. One of the main ways this farmer convinced the general public was by writing a paper where he mentioned the need for another crop other than corn that could provide nutrients that corn lacked. In 1903, the Agronomy South Farm was established on the University of Illinois campus and has been growing soybeans ever since(Aoyagi & Shurtleff, n.d). After a couple of years, many farmers began growing soybeans, and by 1914, 2,000 acres of soybeans were being harvested; by 1916, there were 6,000 acres(Aoyagi & Shurtleff, n.d). By the 1920s, soybeans had grown to become a National star crop, with Illinois becoming America's leading producer(Aoyagi & Shurtleff, n.d). In our current history, Illinois counties hold the top spot as the number one producer of soybeans in the United States(Illinois Gov, 2023). In 2022, soybean farmers “raised over 667 million bushels of soybeans on 10.75 million harvested acres, and an average yield of 63 bushels per acre”(Zimmerman,2023). Soybeans, along with another one of Illinois top crops, made roughly \$3.5 billion for the state. Similarly to the previous two crops, corn and rice, we can see that they play vital roles in the agricultural spheres of their states, so farmers, along with their local governments, will do whatever is necessary to continue the growth of this crop.

Agricultural Practices and Shifts in Corn, Rice, and Soybean Production

Corn Agriculture Practices

In Iowa, corn is planted when the soil is warm enough for the seeds to germinate. Typically for Iowa, this occurs in April (“Iowa Corn,” n.d.). Harvesting begins around mid-September, even though most of the harvest takes place in October, yet if it is a cold growing season, then harvesting takes place in November (“Iowa Corn,” n.d.). Once the corn has been picked, the husks off each ear of corn are stripped by modern combines that remove each kernel (“Iowa Corn,” n.d.). These are typically the steps that happen when a farmer is planting corn, but throughout history, the one thing that has changed has been farming techniques.

Farming practices for corn have evolved since early American times. One early technique used by American Indians was to dig a hole in the ground and plant a couple of corn kernels, weeds were chopped out during the growing season, and the labor required was low (“Iowa’s Corn and Agriculture Industry,” n.d.). In the thirties and forties, subsistence farmers who farm for their own consumption would first break through the prairie sod with a newly invented prairie plow (Throne, 1949). This farmer could have a few hogs, a horse, or possibly an oxen; their main tools would consist of a wooden plow, the share sheathed with iron, a sickle, a cradle, and a fail (Throne, 1949). The introduction of things such as horse-drawn plows, planters, tractors, mechanical pickers, herbicides, pesticides, and fertilizers allowed for new corn farming techniques to be developed throughout the years (Throne, 1949). What a majority of these tools were able to do, was that they allowed farmers to plant and harvest crops faster and over a larger piece of land. Compared to how American Indians planted corn to how farmers in the 30s and 40s planted, with inventions like planters and mechanical pickers, work that would have taken days can now be completed within a shorter time.

Rice Agricultural Practices

In 2021, about 57% of the rice produced in this state was planned using conventional tillage methods (Hardke et al., 2022). This method usually involves fall and spring tillage to prepare a seeding bed. Fall tillage is used to “break up residue in order to help speed up its deterioration,” spring tillage, on the other hand, is used to “prepare the surface for level, low residue planting in order to enhance uniform emergence” (“Overview of Tillage Systems,” n.d.).

A majority of the rice is produced in a dry-seeded and delayed-flood system. This means that the seed of a crop is planted dry, and then flooding begins when the rice reaches the four or five-leaf stage, and water levels are maintained until the crop is dried down before harvest(Tatum, 2019). Water is something that is extremely vital to the successful growth of rice, so in order for Arkansas to grow successful rice, farmers use irrigation water and groundwater to water the crops(Hardke, 2021).

Once the crop has been harvested, it is important to reprepare the soil for the next cropping season. Some techniques that were used for this were tillage, burning, rolling, and winter flooding(Hardke et al., 2022). For example, if “a significant amount of the acreage that is flooded during the winter for waterflow will also be rolled”(Hardke et al., 2022). Unlike a crop like corn, which went through many stages of agricultural practices, it has always been known to farmers that in order to grow, harvest, and economically benefit from a crop like this, it would require large machinery(Hileman, 1949). For example, in the average life of a rice farmer in 1947, planting begins in the early spring, when tractor power plows and discs are used to loosen and pulverize the soil(Hileman, 1949). After, levees and dikes are built, and seeding begins around May(Hileman, 1949).

Soybean Agricultural Practices

Soybeans are one of the most versatile and resilient plants in the United States. In the United States, soybean farming typically involves growing genetically modified and non-genetically modified soybeans using both conventional and organic farming techniques(SoyConnection, n.d). Soybeans are typically harvested in the fall when they have matured, which is noted when the leaves of the crop start to turn yellow. When the leaves fall off, the soybean pods are exposed and ready to be harvested(SoyConnection, n.d).

Since soybeans are one of the most flexible crops to grow, they can easily be grown in a number of different production systems or cultural practices(“Soybean Cultural Practices,”n.d.). Because U.S. soybeans are able to be grown over a wide variety of geographical areas and in a variety of climates, how a farmer chooses to grow them is incredibly important(“Soybean Cultural Practices,” n.d.). Four of the main management decisions that farmers consider are type of tillage, plant population, row spacing, and planting date(“Soybean Cultural Practices,” n.d.).

For example, planting dates have a variety of dates since it depends on whether the soil has enough moisture. Farmers who tend to seed earlier need to be extra careful and check that their seedbeds are in good condition(“Soybean Cultural Practices,” n.d). If they are not, their yield of crops could decrease instead of increase(“Soybean Cultural Practices,” n.d). Similar to rice, since their introduction to the Americas was rather late, farming machines were available to farmers, making growing rice a bit more simpler.

Historical Shifts in Agricultural Practices

From the practices discussed above, we can tell that throughout these crops' history, there have been shifts in agricultural practices. Most of these shifts can be seen in the tools that farms used to harvest and grow their crops. For example, there are shifts from how American Indians planted crops with their hands to how colonizers used smaller devices like a plow, then from plows to big mechanical devices like tractors. While these shifts are really important, one major shift that we have not hit on is the introduction of fertilizers to crops.

Similarly to how we learned about how to grow crops from American Indians, we also might have learned the concept of fertilizers from them too. Fertilizers are defined as “ any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for the plant growth”(“Fertilizer Management,” n.d.). They are commonly used in agriculture around the world and contain basic plant nutrients like nitrogen(N), phosphorus (P), and potassium (K)(“Fertilizer Management,” n.d.). They are usually applied to crops to replace the essential nutrients for plant growth in the soil after it has been depleted(“Fertilizer Management,” n.d). Before the creation of chemical fertilizers, “ the first English settlers in North America reported that the Indians substantially increased their yield in maize by burying a fish with each seed they planted”(Pratt, 1965). We can infer that they did this because it was apparent that animal droppings and carcasses were natural fertilizers that helped plants grow(Pratt, 1965).

Before the introduction of chemical fertilizers in the states, there was some talk about improving farmland that had been worn out, and because of this, farmers became interested in manure(Taylor, 1953). In the antebellum period, manure and compost were in high demand to help replenish farmland, yet it was never enough to cover all the land that was being used(Taylor,

1953). While it is uncertain when exactly chemical fertilizers finally made their way to the states, it is safe to say that they made quite an impact since they are still used today, even though they are causing environmental damage. By now, we must know that fertilizers can lead to water pollution because of the excess nutrients, like nitrogen, that flow from these farms into our streams, disturbing the aquatic ecosystem and potentially affecting ocean waters (“The Fertilizer Threat, 1976). So if people know this, why continue purchasing and using fertilizers? The answer to that is the way that fertilizer is advertised and explained to farmers. Looking back at the history of corn, rice, and soybeans, one major thing they all had in common was that the amount of crop they produced was extremely important to the economy of their respective states. So when companies or people are advertising the positives of fertilizers, their main selling points are that they help increase crop yields and replenish the nutrients that soil needs to grow crops. For example, in an article titled “Chemical Fertilizers” written by Christopher J. Pratt, he begins by stating that with the growing world population, we have to make sure there is enough food to feed everyone, but that could be a struggle since most of the earth’s unused land is too dry to be used (Pratt, 1965). This is when he mentions how fertilizer can be applied on these under-fertilized lands and have dramatic results, which could allow that land to be used to grow crops (Pratt, 1965).

Figure 1:



Figure 2:

NINE GOOD REASONS
For Using
“HOMESTEAD.”

1st. Because it gives the crop a quick, vigorous start.
2d. It matures the crops from ten to fifteen days earlier, thereby, in many cases, saving the entire crop from early frost.
3d. It will increase your crop from 50 to 100 per cent.
4th. It adds a permanent value to your soil.
5th. You cannot keep up the fertility of your soil unless you restore to it what you take away by constant cropping.
6th. It will always prove what it is recommended to be, a genuine BONE BLACK FERTILIZER.
7th. None sent to market till analyzed and known to be up to the required standard.
8th. It is reduced to a fine, dry powder, which can be sown with a drill, thus insuring a greater economy in its use in grain crops.
9th. Homestead has stood the test of years, and the best farmers use it because of its well-known worth and reliability.

GUARANTEED ANALYSIS.

Available Phosphoric Acid.....	8.00 to 11.00 per cent.	
Equal to Available Bone Phosphate.....	18.00 to 24.00	“
Soluble Phosphoric Acid.....	7.00 to 10.00	“
Equal to Soluble Bone Phosphate.....	15.00 to 22.00	“
Nitrogen total Available.....	1.85 to 2.40	“
Equal to total Available Ammonia.....	2.25 to 3.15	“
Potash Sulphate.....	2.75 to 3.50	“

— MANUFACTURED BY —
MICHIGAN CARBON WORKS,
DETROIT, MICH.
For Sale by

[OVER.]

Source: Michigan Carbon Works, 1870-1900

Description: Advertisements and Postcards from the Michigan Carbon Works titled “Use the Homestead Bone Black Fertilizer.

As we can see from figures 1 and 2 above, the wording in this advertisement and postcard proves that fertilizer companies appeal to the fact that fertilizers can improve soil and increase crop yields, bringing in more money. For instance, figure 2 states, “ It will increase your crop from 50 to 100 percent,” and “It adds a permanent value to your soil”(Michigan Carbon Works, 1870-1900). Now that we understand a little more about the shift to fertilizers and why farmers might be inclined to purchase and use them despite their negative environmental impact, it is now time to look into the amount of fertilizer our crops use and their possible connection and history to water pollution, caused by agricultural runoff.

Fertilizer/ Impact of Fertilizer

Why Use Fertilizer

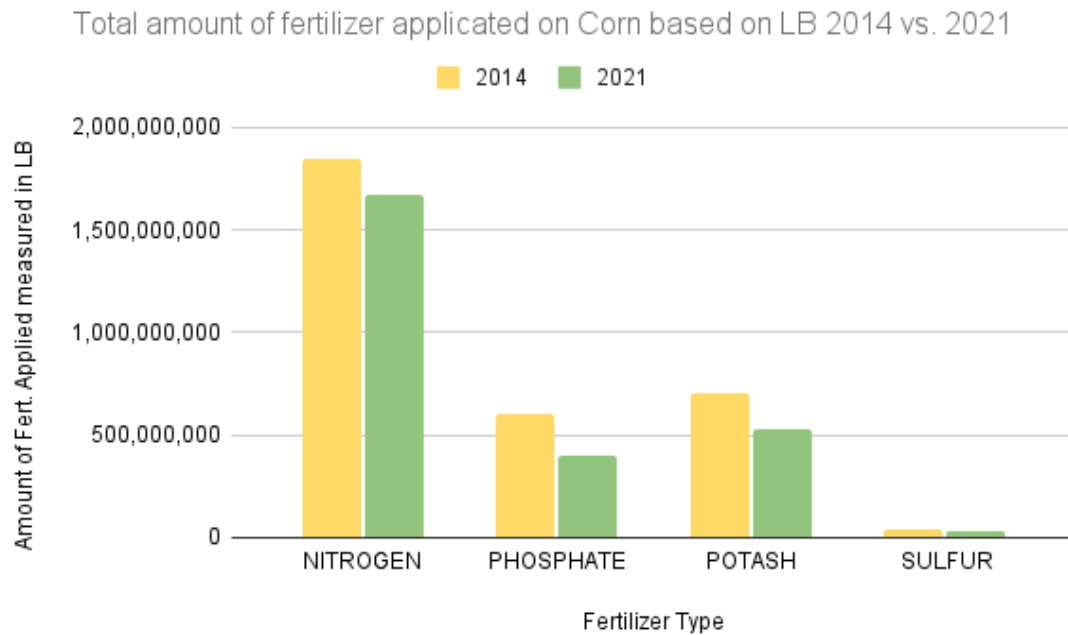
As previously mentioned in the section above, there can be multiple reasons why farmers are choosing to use fertilizers. The list could range from farmers wanting to replenish their soil with new nutrients to farmers wanting to use them to increase their crop yield. In terms of Corn production and growth, fertilizers can help the crop grow in height, which could increase the amount of money farmers are making because they will be producing larger amounts of corn(Quinn et al.,2020). During planting, it is recommended to place the fertilizer 2 inches to the side and 2 inches below the corn kernel at planting(Quinn et al.,2020). Unlike some other crops, corn is a bit special regarding nitrogen. Nitrogen makes up roughly 78% of our atmosphere, yet plants like corn cannot use the nitrogen that is present in the air; instead, it must use its roots to get the nitrogen from the soil, which is why it is important where the fertilizer is applied(Mueller,2019). Similarly to corn, fertilizers, specifically nitrogen fertilizers, are also used to help with the growth of the crop. If rice does not receive sufficient nitrogen, the plant growth can be stunted, the leaves will begin to turn a yellowish-green color, and the yields will be smaller due to fewer grains per panicle(Rice Knowledge Bank, n.d.). This information shows that corn and rice have a seemingly simple relationship with fertilizer, yet the same cannot be said for soybeans. While soybean production uses fertilizer, farmers must be more concerned about how they distribute it to the crop. For example, “fertilizer should not be placed with the soybean seed due to the risk of seedling injury”(Ferguson et al.,2006,p.2). Unlike the other crops that seem to sometimes be overly fertilized, the soybean plant does take some of the nitrates from the soil before farmers come and put fertilizer on it(Ferguson et al.,2006,p.2).

Fertilizer data: Corn, Rice, and Soybeans

Now that we have an understanding of why fertilizer is used on these crops, it is time to take a close look at exactly how much fertilizer is put on these crops annually. Every year the National Agricultural Statistics Service(NASS) conducts hundreds of surveys and prepares reports about every aspect of agriculture in the United States. One of the surveys the NASS conducts can tell us, on average, how many pounds of fertilizer is used in crops depending on the state you are looking at. Figures 3 through 5 show us the average amount of fertilizer depending

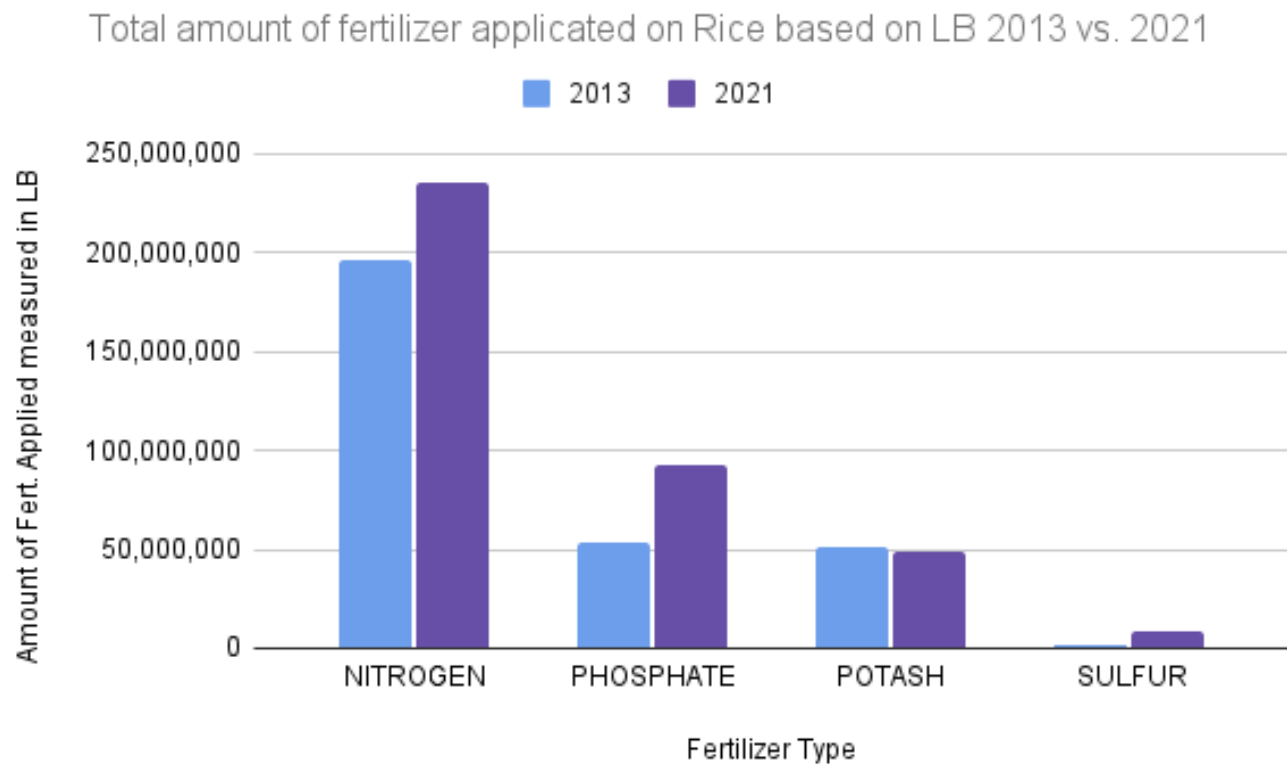
on which chemical (nitrogen, phosphorus, sulfur, etc.) is put annually on corn in Iowa, rice in Arkansas, and soybeans in Illinois.

Figure 3:



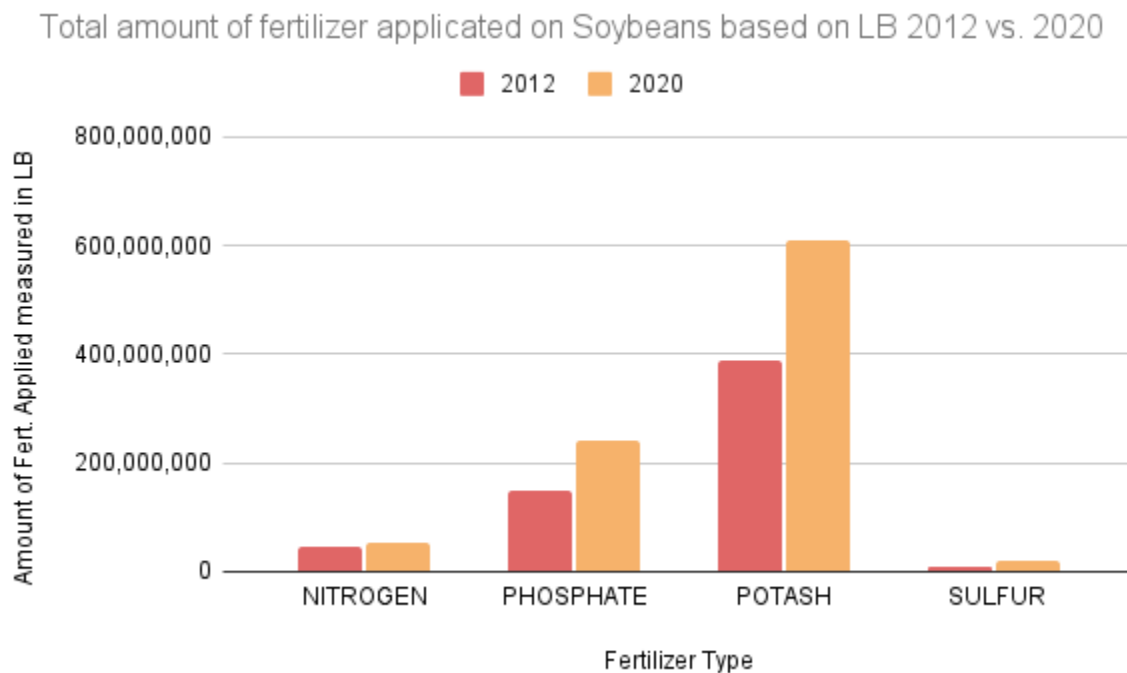
Source: National Agricultural Statistics Service, 2014 and 2021

Figure 4:



Source: National Agricultural Statistics Service, 2013 and 2021

Figure 5:



Source: National Agricultural Statistics Service, 2012 and 2020

Based on all these graphs, and on some crops, we can see some apparent trends, which is why, when gathering this data, I pulled from two different years to see what similarities or differences we could see. Figure 3 shows the annual amount of fertilizer applied to corn in Iowa during the years 2014 and 2021. Based on the data, we can see a decrease in the amount of fertilizer used, not just within one category of fertilizer but within all that were recorded. Figures 4 and 5 covered data from rice grown in Arkansas from 2013 and 2021 and from soybeans in Illinois from 2012 and 2020. Comparing this data to the data in figure 3, there was a complete increase in the amount of fertilizer used annually on these crops. The one thing I would like to point out is that even though Corn had a decrease, their numbers during those years were in the billions rather than in the millions like the other crops, so while at first glance it might have looked like farmers in Iowa were limiting their amount of fertilizer use, they were still using more than farmers in other states like Arkansas and Illinois.

The amount of fertilizer that was put on these crops annually was extremely overwhelming. As we know, Iowa is the largest producer of corn in the United States, but it is also the “second largest producer of nitrate pollution in the Mississippi River Basin”(Royte,2017). On average, the state of Iowa “contributes between 11-52% of the long-term nitrate load to the Mississippi-Atchafalaya Basin, and 20 to 63% to the Upper Mississippi River Basin”(Jones et al., 2018, p.1). Looking at the amount of fertilizer put on corn in Iowa, I can only imagine how much of that fertilizer found its way into the Mississippi River and then into furthering the spread of the Dead Zone in the Gulf. In June of 2022, the federal government made an announcement that they would be distributing \$60 million among 12 states that have waters that flow into the Mississippi river with the hope that the money could help them control farm runoff and other pollution that is contributing to the dead zone(The Associated Press, 2022). Out of those 12 states, all three of our states were on the list: Iowa, Arkansas, and Illinois. Further proving that agricultural runoff was a serious problem in desperate need of attention. Attached with the money was a note from the Environmental Protection Agency that gave the states some guidance on how to spend the money. Some of these things included “implementing continuous real-time water quality monitoring and developing or revising numeric nutrient criteria and water quality standards.”(The Associated Press, 2022). By this point, we have seen how much agricultural runoff affects our nation's waters. But what exactly can be done to limit the amount of fertilizer entering the water from agriculture? The United States is known for its environmental policies. One in particular, The Clean Water Act, focuses on limiting pollution. So what is the policy? And does it have the power to limit agricultural runoff?

Chapter 3

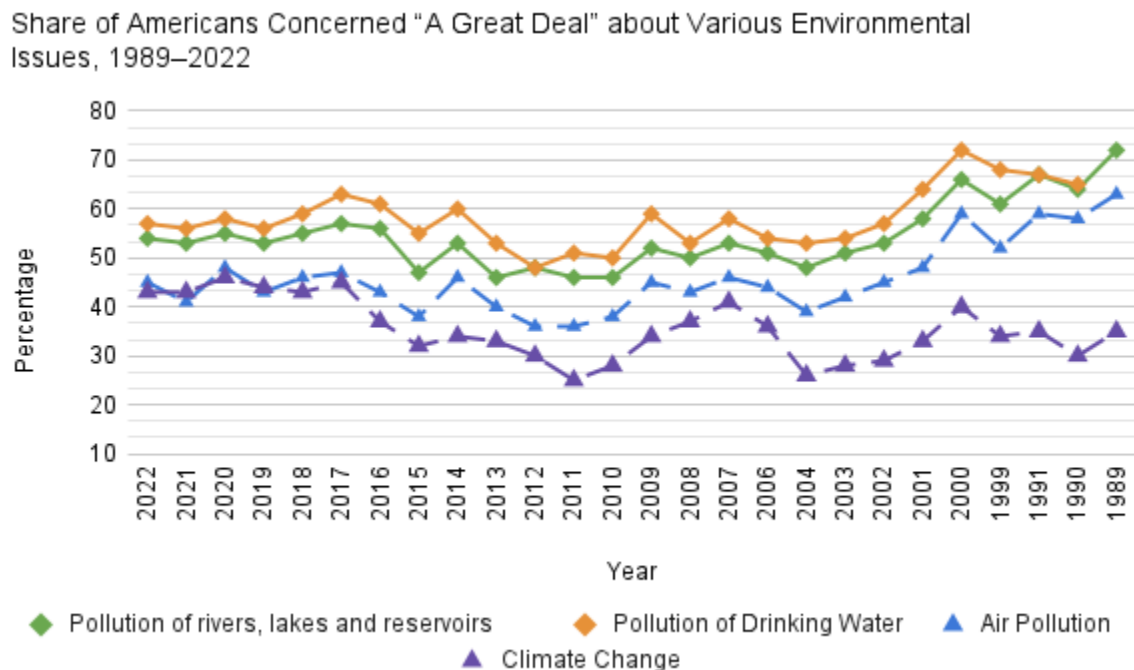
History Before the Clean Water Act

There are multiple environmental laws and regulations that protect water, one of them being the Safe Drinking Water Act. However, the Clean Water Act(CWA) is the primary statute regulating water pollution at the federal level. Before this act was introduced, the task of controlling water pollution fell into the hands of the state legislature(Hines,2012). The main reason was that there was a lot of resistance to the idea of federal regulation because there was a belief that dealing with such pollution was strictly a state or local matter(Hines, 2012). In the 19th century, because of the large amount of pollution found in state waterways, concern started spreading among many states that local governments created state agencies. Their main goal was to regulate pollution in their state waterways(Hines, 2012). During the time that the states were in control of water pollution, their laws and policies were relatively weak. Some exceptions were in states where much of their tourism depended on safe and clean drinking water(Hines, 2012).

Another thing that made these state agencies' policies and regulations weak is their level of enforcement. For example, those in charge of these agencies “much preferred a strategy of offering inducements and friendly persuasion to one of confronting polluters with legal action(Hines, 2012, p.4). Because of the continued pollution, the federal government in the late 1930s decided to implement policies to limit water pollution across all 50 states(Dworsky,1967). One of them was The Federal Water Pollution Control Act of 1948. The 1948 Act included the basic elements of financial and technical aid, research, and a modest form of enforcement on water pollution(Dworsky,1967). What this act gave the federal government was jurisdiction over the control of pollution in the waterways. When it was first amended in 1956, it added a clause that stated that the government was not trying to impair or affect the rights of the states when it came to the respect of the water boundaries in each state(Dworsky,1967). In 1965 the act was amended once again, and in this amendment, there were two additions, yet the first addition was the most important. The first addition made the purpose and intent of this Act more clear; it stated that its purpose “is to enhance the quality and value of our water resources and to establish a national policy for the prevention, control, and abatement of water pollution”(Dworsky,1967,p.653).

Even though the federal government was now playing a role in trying to control water pollution, more and more concerns from the public started to grow. In the late 1960s and early 1970s, “two-thirds of the nation's lakes, rivers, and coastal waters were unsafe for fishing or summing, and untreated sewage was dumped into open waters”(Environmental Works, 2018). One main event that drew a lot of attention on this subject was the Cuyahoga River because it caught on fire multiple times. In 1969, the river caught on fire, which lasted for roughly 22 minutes; the waters were so heavily polluted with waste that a *Time* magazine article even went as far as to say that “Anyone who falls into the Cuyahoga does not drown, he decays”(Keiser & Shapiro, 2019). Pollution in our waterways, along with pollution in our drinking water, has been a cause for concern for the longest time. Even though the federal government was trying to address the issues with policies like The Federal Water Pollution Act, public concern was still rising. In our current history, the US Gallup conducts a poll that showcases the concerns of Americans; water pollution has been a top environmental concern for the past 30 years(Keiser & Shapiro, 2019). Figure 6 below shows the percentage of Americans who report that they are concerned about environmental problems.

Figure 6:



Source: Gallup (2022).

Description: Each poll question asks, “I’m going to read you a list of environmental problems; as I read each one, please tell me if you personally worry about this problem a great deal, a fair amount, only a little, or not at all” The graph only shows four out of twelve questions.

As we can see, there has always been a high percentage of Americans concerned with environmental issues like water pollution. Because of the increased pressure and concern from the public, on July 9, 1970, President Nixon relayed a message to congress about plans to establish the Environmental Protection Agency(EPA) and the National Oceanic and Atmospheric Administration(NOAA). Nixon states, “it has become increasingly clear that we need to know more about the total environment-land, water, and air. It has also become increasingly clear that only by reordering our federal efforts can we develop that knowledge and effectively ensure the protection, development, and enhancement of the total environment itself”(Reorganization Plan No. 3 of 1970). The EPA was finally established on December 2, 1970; its mission would center on:

- The establishment and enforcement of environmental protection standards consistent with national environmental goals.
- The conduct of research on the adverse effects of pollution and on methods and equipment for controlling it; the gathering of information on pollution; and the use of this information in strengthening environmental protection programs and recommending policy changes.
- Assisting others, through grants, technical assistance, and other means, in arresting pollution of the environment.
- Assisting the Council on Environmental Quality in developing and recommending to the President new policies for the protection of the environment.

Source: The Guardian: Origins of the EPA,1992

The Clean Water Act

With the creation of the Environmental Protection Agency came new acts, one of the main ones being the Clean Water Act(CWA). The United States introduced the Clean Water Act in 1972 under the Nixon administration. The act's primary goal was to "restore and maintain the chemical, physical, and biological integrity of the nation's water" (Collaku, 2016, p.442). In order to achieve this goal, the CWA generally "prohibits the discharge of pollutants into waters that fall within the scope of the statute's jurisdiction" (Collaku, 2016, p.442). The CWA was mainly created to protect the health of the American people. According to Professor William Hines, "water pollution rendered the country vulnerable to serious health problems arising from the disease-carrying capacity of our polluted watercourses" (Glicksman, Batzel, 2010, p.100).

The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless they have a permit(Foster & Matlock, 2001). Under section 502(14) of the Clean Water Act, it defines that a point source "means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel; conduit, wee, discrete fissure, container, rolling stock concentrated animal feeding operation, or vessel or other floating craft, from which pollutants may be discharged. This term does not include agricultural discharges and return flows from irrigated agriculture"(Miller,2015, p.2). In its original form, the CWA had three explicit goals:

1. Discharges of pollutants into navigable waters will be eliminated by 1985(zero discharge goal).
2. Whatever is attainable, an interim goal of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on water be achieved by 1983 (fishable and swimmable goal).
3. The discharge of toxic pollutants in toxic amounts is prohibited (no toxins in toxic amounts goal).

Source: Foster & Matlock,2001,p.26.

Similarly to many other environmental acts, the Clean Water Act of 1972 was amended many times. Congress made some amendments in 1977, revised portions of the law in 1981, and made other amendments in 1987(Bearden et al., 2013). In 1977, one of the changes was that the Act

could also be cited as the “Federal Water Pollution Control Act”(Public Law 95-217, 1977). One of the major things these amendments accomplished was that it gave the Environmental Protection Agency more power and control. It gave the EPA the authority to develop programs for controlling wetlands, and it gave them the authority to clean up oil and hazardous substance pollution 200 miles from the shoreline(Public Law 95-217, 1977). Amendments were mostly focused on toxic pollutants; they required industries to meet available technology standards for specific pollutants by July 1, 1984(Public Law 95-217, 1977). In 1987, the Clean Water Act was amended once again. In these additions, they authorized citizen suit provisions(Public Law 100-4,1987). This means that citizens of the public are allowed to initiate lawsuits in federal court against actors, including corporations, that are in violation of requirements that have been put in place by federal environmental laws(Environmental Rights Database, n.d). These new additions also created the Clean Water State Revolving Fund (CWSRF), to be used to fund projects that improve water quality, in things such as municipal water treatment facilities or nonpoint source pollution(Public Law 100-4,1987). Another addition to these amendments was section 319, Nonpoint Source Management Program; this section was to work hand and hand with the CWSRF and help states tackle nonpoint source pollution(Public Law 100-4,1987). Prior to these changes, nonpoint sources like stormwater runoff from agricultural lands, forests, construction sites, and urban areas were not covered under the CWA, even though they represent more than 50% of the nation’s water pollution problems(Bearden et al., 2013). In order to combat these issues, the 1987 amendments authorized measures to address this issue by directing states to develop and implement management programs against nonpoint source pollution(Bearden et al., 2013).

Forty years after the installment of the Clean Water Act, surface water quality has improved considerably. However, the goal of eliminating pollution in surface water entirely is still a long way ahead (Glicksman, Batzel, 2010). While there is still a large amount of pollution in our waters, in order to see how well the CWA has done, we have to remember how our waters were before it existed. Before the CWA, “industrial and municipal wastewater was being dumped into streams, rivers, and lakes in many places without treatment”(Solliday,2022). Now that we have this act, events like the Cuyahoga river burning are not happening much. When they do, it receives a lot of media attention because it is seen as a relatively unusual occurrence(Solliday,2022). In a study by researchers at UC Berkeley and Iowa State University,

they analyzed data from 50 million water quality measurements collected at 240,000 monitoring sites throughout the United States between 1962 and 2001. Their results showed that there was an improvement in the water; there was an increase in dissolved oxygen concentrations and a decrease in fecal coliform bacteria(Manke,2018). In terms of dissolved oxygen, it is important to figure out the water quality of a source because depending on how much-dissolved oxygen there is in the water depends on whether that source can support aquatic life(Atlas Scientific, 2022). Fecal coliform bacteria in our water is a good way to determine how polluted a water source is(5.11 Fecal Bacteria, n.d). So the fact that there was an increase in dissolved oxygen and a decrease in fecal coliform bacteria is a good indicator that the water quality is improving in these areas. These samples were taken in the years before and after the implementation of The Clean Water Act, so from this, we can see that the act helped decrease pollution and improve water quality. As we know, through the CWA, the Environmental Protection Agency has been able to incorporate programs to regulate the effects of pollution on water resources. Because of this, countless bodies of water across the country have been improved. For example, one of the bodies it helped restore was the Charles River in Boston. Before the Clean Water Act, the river was nearly inhabitable for marine life(Safdie,2023). Through the help of the CWA, utilizing several state, federal, and local agencies, and nonprofit organizations, the Charles River was restored using technology to determine which pollutants were in the water(Safdie,2023). From these examples, we can see the positives that the Clean Water Act has accomplished.

Not only did the CWA improve our water quality, but it also helped bring awareness to environmental rights. During this time, there was a lot of talk about the environment's future and what our government could do to help. Another effect of the CWA was that it affected the way industries worked and how they affected the environment. The CWA was an established policy that made it clear to industry and municipalities alike that pollution control would be expected over the next decade (Glicksman, Batzel, 2010). Now that the federal government has tight control over water pollution, the CWA allowed them to implement programs against water pollution. Industries had to find new ways to dispose of chemicals properly, and sometimes that could be expensive. This ultimately led to companies finding other ways to dispose of their waste, sometimes at the expense of others and the environment.

CWA's Role in Ag. Runoff from Miss. River to the Gulf

As we can see, the Clean Water Act has made a significant amount of change when it comes to regulating pollution from point sources. Yet, the CWA largely ignores agricultural pollution, which contributes to some of the worst water quality problems(Keiser&Shapiro,2019). One of the major drawbacks of the Clean Water Act is that it does not give the federal government control of the restrictions on nonpoint sources, but rather that power is handed over to the states. As previously stated, the 1987 amendments to the Clean Water Act were where we saw some decisions being made about how to limit pollution from nonpoint sources. The federal government's response was to create section 319 Nonpoint Source Management Programs and the State Water Pollution Control Revolving Funds. Before going into how those programs truly work, it is important to note how the Environmental Protection Agency defines a nonpoint source: “Nonpoint source pollution(NPS) generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydraulic modification. Unlike pollution from industrial and sewage treatment plants, NPS pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and ground waters”(EPA,“ Nonpoint Source (NPS) Pollution). As we can see from this definition, Nonpoint source pollution is just as common as point source pollution, so it should be handled and dealt with just as fiercely as point source pollution.

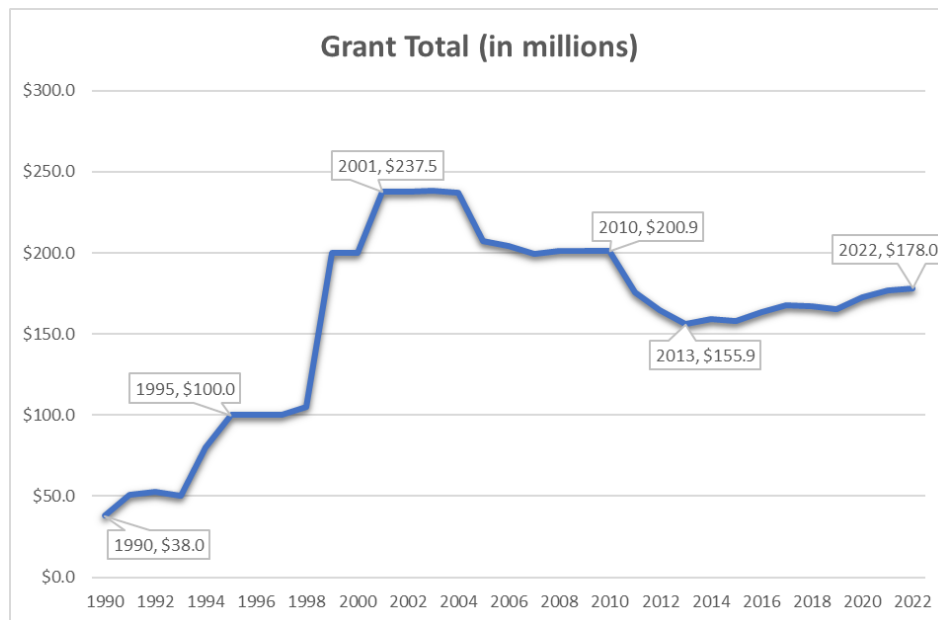
The State Water Pollution Control Revolving Fund is a program that was added to the Clean Water Act in 1987. This program states that a general authority should make capitalization grants to each state for the purpose of establishing a water pollution control revolving fund for providing assistance “(1) for the construction of treatment works which are publicly owned(2) for implementing a management program under section 319 and(3) for developing and implementing a conservation and management plan”(Public Law 100-4,1987). Section 319 Nonpoint Source Management is a program that has the Governor of each state should prepare and submit a report which:

“(a) identifies those navigable waters within the state which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain

applicable water quality standards or the goals and requirements of this act; (b) identifies those categories and subcategories of nonpoint sources or, where appropriate, particular nonpoint sources which add significant pollution to each portion of the navigable waters identified under subparagraph (A) in amounts which contribute to such portion not meeting such water quality standards or such goals and requirements; (C) describes the process, including intergovernmental coordination and public participation, for identifying best management practices and measures to control each category and subcategory of nonpoint sources and, where appropriate, particular nonpoint sources identified under subparagraph (B) and to reduce, to the maximum extent practicable, the level of pollution resulting from such category, subcategory or source; and (D) identifies and describes State and local programs for controlling pollution added from nonpoint sources to and improving the quality of, each such portion of the navigable waters, including but not limited to those programs which are receiving Federal assistance”(Public Law 100-4,1987).

As we can see from these two programs, their main goal is to give states adequate access to funding to help them reduce pollution from nonpoint sources that are entering their waterways. In terms of the CWSRF, in 2022, it has been able to provide \$163 billion to communities, and states have provided over 46,200 low-interest loans to protect public health and aquatic resources and meet environmental standards that have benefited hundreds of millions of people(EPA,” Clean Water State Revolving Fund”). Like the CWSPF, the section 319 program has provided millions to states throughout the years. In figure 7 below, we can see that once the program was established, it took a while for states to apply for these grants, but in certain years we can see spikes in the amount of money awarded. We can infer from the data that this program was being used to its best ability.

Figure 7:



Source:“ 319 Grant Program for States and Territories,” 2022

Description: Values for most years are rounded to the nearest \$100,000.

While this might be a good first step in addressing the larger issues that come from nonpoint sources, many people believe that the Clean Water Act falls short when addressing these areas that cause mass pollution and larger environmental issues.

Regarding the agricultural runoff from fertilizers flowing into the Mississippi River down to the Gulf of Mexico, the Clean Water Act categorizes this type of pollution as coming from a nonpoint source(Laitos & Ruckriegle, 2013). This means the act removes these sources from federal oversight; instead, its regulation is in the hands of the states. Compared to a federal regulation that is required for all states to follow unless they have applied for an exception, the states were directed, but not required to establish the best management practices to combat these sources of pollution(Laitos & Ruckriegle, 2013). Overall, regarding how the Clean Water Act affects fertilizer runoff that is causing the dead zone in the Gulf of Mexico, the Act's role is minimal. True power lies in the state and local governments in states that are contributing to this pollution.

Conclusion

At this point, it is difficult to ignore the fact that one of the main causes of the dead zone in the Gulf comes from agricultural runoff, more specifically from fertilizer runoff. Through the histories of Corn, Rice, and Soybeans, we have seen that there has always been a chance of pollution through their practices. However, when fertilizers were introduced, crop pollution went from being a chance to something expected to come. With how much fertilizer is being put on these crops, pounds, and pounds of chemicals are entering our waterways, causing more and more issues, not just environmental issues, but it could also possibly affect the lives of people who live along these bodies of water. In order to attack and potentially solve this problem changes need to be made to the current environmental policy we have in place. While the Clean Water Act might have solved the issues it had when the policy was first established, it needs to be updated to help solve the issues that are affecting us now actively. With the Clean Water Act, we learned that when dealing with pollution from nonpoint sources, the federal government developed programs for the states to come up with strategies to limit further pollution. In order to understand what steps are being taken at the state level, I believe it would be interesting to look out at what states have done with the money from these programs. Are the programs even helping the problem? Another thing worth looking into would be the steps required to amend a policy and, if you were able to, what changes could be made so that this problem, agricultural runoff, is maintained and limited. The dead zone is constantly growing, and we need to find a way to stop the spread, and one of those ways is to bring awareness to one of its main causes. This research does just that; it gives readers information and data they might not have seen anywhere else. It opens their eyes to the shortcoming we have in our environmental policies. However, now, with this attention, there is hope that people will speak up and start asking for changes.

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