FUELING WITH ETHANOL: GROUNDBREAKING OR A CORNY JOKE

by

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ABSTRACT

This thesis investigates implications relative to the production and use of corn ethanol as a fuel source in the United States. In simple terms, such implications encompass both, impacts on the environment, and economic consequences on the national scale. Discourse in this thesis challenges an understanding of renewability regarding corn ethanol by illustrating a negative energy balance in the production of the fuel source. To add, analysis on carbon dioxide demonstrates that using ethanol leads to more greenhouse gas emissions being emitted into the atmosphere than gasoline when one takes into consideration all sources of energy used in the production of corn ethanol. The paper further analyzes corn ethanol in context of the water network. Such context includes irrigation rates, water pollution, and how pollution impacts both, human health and U.S. citizens' financial means. Such financial implications are predicated on federal subsidies, taxes and how the destruction of underwater ecosystems wreak havoc on fishing communities and the hospitality business. The paper will note that political motives for implementation of corn ethanol include a goal to achieve renewable energy and lower U.S. dependence on Middle Eastern oil. However, research illustrates that broad incorporation of corn ethanol as a fuel source leads to a conflict of goals outlined by the Environmental Protection Agency by facilitating water contamination. Ultimately, this paper will conclude that the renewable elements of corn ethanol are limited, and in some cases the use of ethanol has deleterious effects on ecosystems and economic construct in the United States.

Introduction

In the twenty-first century, the United States has embraced crop grown resources. More specifically to the topic of this thesis, U.S. citizens embrace corn for production and use of ethanol. Today, fuel is nearly as vital to the American way of life as food and other high demand commodities. In accommodation, the need to mitigate harmful levels of greenhouse gas emissions is an area of focus for governmental agencies. Furthermore, corn ethanol is regarded as a practical fuel source that contains substantial energy for internal combustion engines. For the mentioned reasons, biofuels derived of corn have been accepted by politicians as a solution to increasing demand to mitigate ecological footprint and satisfy the need for fuel. Evidence for the above claim is evident when the George Bush Jr. administration passed legislation, including amendments to the Renewable Fuel Standard to institute ethanol at a higher rate in U.S. society. Thus, the perceived benefits of biofuels have prompted bipartisan support in politics by appeasing both, environmental and economical perspectives.

The idea to fuel U.S. tanks with ethanol was first seriously considered during the oil crisis in the 1970s to lower dependence on foreign oil. The Clinton administration supported the fuel source under the pretense that ethanol was a renewable fuel source capable of producing lower levels of greenhouse gas emissions like carbon dioxide than its gasoline counterpart. However, Clinton’s administration did not support the fuel source as extensively as that of Obama and especially the administration of George Bush Jr. The motive to expand renewable American fuel and mitigate climate change was supplemented by geopolitical goals to decrease U.S. dependence on Middle Eastern oil. Applicably, fueling with and supporting movements toward ethanol in the United States is intuitively prudent to many. The production of such a fuel can make jobs for Americans, reduce the need for inter-global fuel transportation, mitigate offshore oil spills and help improve the environmental state overall. However, some evidence suggests that growing crops specifically for the use of producing ethanol (especially corn/maize type ethanol) is not beneficial to the environment.

The three enclosed chapters will provide evidence and analysis to challenge claims of economic feasibility, practicality, and environmental renewability of corn as a fuel source. Chapter one will discuss practicality and economic feasibility by analyzing non-corn-based energy sources needed in the production of corn ethanol. Furthermore, the chapter will investigate the claim of fewer greenhouse gas emissions in the burning of ethanol. The second chapter grapples with claims of renewability in terms of the U.S. water network. Investigation is relative to irrigation, health effects of high nitrogen water, and how both nitrogen and potassium contamination in rivers and oceans has led to financial turmoil and health hazards due to harmful algal blooms. Finally, chapter three provides discourse for motives and proponents in favor of growing corn to accommodate the need for fuel in the United States. The chapter will discuss financial winners in contrast to those who lose. Evidence will indicate that politicians' support of subsidizing the fuel source is paramount to the perpetuality of the fuel source in the United States. Ultimately, the chapter will argue that support of corn ethanol by the Renewable Fuel Standard is intended to appease farmers in exchange for earning votes from agricultural communities.

Chapter 1: Practicality of Ethanol as a Fuel Source

Specific to this chapter, evidence indicates that corn ethanol may not be fuel efficient in certain situations. In construct, this chapter will implement six subsections to provide discourse on corn ethanol, and its viability as a fuel source. This chapter will compare the perceived practical tenets of corn ethanol in contrast to conflicting evidence on basis of economy, carbon dioxide emissions and energy balance. Upon investigation, the chapter will illustrate that corn ethanol is neither renewable, nor an economic fuel source due to a negative energy balance that uses an unnecessary amount of energy and resources, while producing a comparable amount of carbon dioxide emissions as gasoline.

1.1: Use of Corn Biproducts and Erosion

One article looked to provide discourse regarding the viability of biomass (vegetation) in terms of sustainability and practical use. The publication *Conditions for the sustainability of biomass based fuel use* by L. Reijnders (a Netherland scientist) consolidates a number of perspectives to help us analyze the renewability of plant based fuel sources. One such example grapples with ecosystem displacement and deforestation. Furthermore, the publication investigates how such elements are in some way, relative to societal support for ethanol. First, it is important to note that this article considers that soil sources vary widely across the United States. Making note of differences in the soil is important because analysis of sustainability regarding crops for fuel tend to neglect that soil contributes to overall implications in research.[1] Thus, it should also be noted that studies conducted on crops, and their conclusions regarding sustainability on fuel production is to a degree subjective on a macro level analysis. However, the source provides considerable discourse for soil and the impact that increased farming has on soil-health. The article notes that added farming in response to a growing demand for ethanol has led to deleterious implications on soil in the United States. Reijnders eludes that the loss in soil nutrition is affected by over farming and erosion. To add, Reijanders says “resources conservation requires that loss due to erosion should be balanced by soil formation due to such processes as natural weathering.”[2] The quote indicates that rapid use of soil leads to erosion and a negative effect on the likelihood that crops will continue to perform well when sown into unrested soil. Additionally, Reijanders adds that increased farming can lead to ecosystem destruction and deforestation. The author does offer that erosion and decline in nutritional elements of soil can be somewhat mitigated by leaving “crop residue” on fields.[3] Furthermore, Reijnders eluded that burning crop residues can lead to detriment of soil health through nutritional loss and erosion. As stated above, Rejinders studies and conducts research in the Netherlands. This is important to consider because qualities of soil likely differ (drastically in some areas) between the Netherlands and the United States. Furthermore, the practice of burning crop residue in the United States is not widely utilized. To provide clarity, crop residue describes left over deposits from harvest like chaff or fodder. While unable to represent

[1] L. Reijnders “Conditions for the sustainability of biomass based fuel use” Energy Policy Vol. 34, 2006, 865.
[2] L. Reijnders “Conditions for the sustainability of biomass based fuel use” Energy Policy Vol. 34, 2006, 865.
[3] L. Reijnders “Conditions for the sustainability of biomass based fuel use” Energy Policy Vol. 34, 2006, 866.

biomass to the same degree as a plant complete with the seed such as corn cobs in the realm of corn plants, left over fodder contends to be a prudent resource for fuel. Fodder and chaff are biproducts of crops that are grown for the purposes other than producing fuel. Often, corn fodder is baled for the purpose of feeding livestock, or milled and made into supplements such as distiller-dried-grains. One can infer that utilizing corn biproducts like distiller-dried-grains for fuel is a win-win. In contrast however, Reijnders argues that these biproducts of farmed foodstuffs help replenish nutrients into farmed soil. The author says "judicious planting and harvesting practices" like wind mitigation (trees/hedges), terracing and effective waterways can help control erosion. However, the author adds that terracing and water diversion will likely not alleviate erosion and nutrition loss to an effective extent.[4] Reijnders's quote "use of crop residues is an important determinant of erosion" is evidence of the importance that plant bi products have in the health of tillable soil.[5] Taking consideration of the impacts relative to use of crop residue is significant because it destabilizes a strong argument in viability to renewable tenets of corn ethanol.

1.2: Energy Balance

Now that we have provided discourse for farming and its impact on both erosion and soil health, we will grapple with the practicality of using ethanol and other corn based resources in the fueling of farm machinery. Consideration of the fueling of farm machinery is paramount to deciding the efficiency properties of ethanol. Since nearly all farming of corn and other vegetation includes at a minimum, planting and harvesting

[4] L. Reijnders "Conditions for the sustainability of biomass based fuel use" Energy Policy Vol. 34, 2006, 865.
[5] L. Reijnders "Conditions for the sustainability of biomass based fuel use" Energy Policy Vol. 34, 2006, 865.

phases, in addition to tilling, spraying of herbicide and fertilizing in many cases, ethanol is not a practical fuel option without the advent of farm machinery. Furthermore, such farm machinery requires fuel in its use.

The source *An Exploration of Agricultural Lands Devoted of Corn-Based Ethanol Production* contends that determining net fuel efficiency of corn ethanol is a subject of strong debate.[6] For example, a source endorsed by then governor of Illinois, Jim Edgar titled *Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn* by the Center of Transportation Research and Argonne National Laboratory claims that corn ethanol is an environmental and positive net efficient fuel source.[7] This source studied and compiled data relative to Illinois, Iowa, Minnesota and Nebraska.[8] Considering the states relative to the study is significant in the quest of understanding the efficiency of energy returns respective areas. Accordingly, the four mentioned states "collectively account(ed) for about half of the total U.S. domestic corn harvest" that year.[9] As addressed earlier, differences in soil and rainfall can corelate with higher or lower respective crop yields. In turn, failure to take these data with a grain of salt can establish a skewed and overly favorable representation of such plants energy performance. Illinois, Iowa, Minnesota, and Nebraska are home to some of the best corn growing land in the United States. As such, findings derived from the above states are perhaps, a best-case scenario in terms of planting corn crops for fuel. In contrast to the

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[6] K Colton, Flynn. "An Exploration of Agricultural Lands Devoted to Corn-Based Ethanol Production" Papers in Applied Geography, Vol 2, No 3, 2016, 315.
[7] Christopher Saricks, Michael Wang and May Wu, "Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn" Argonne National Laboratory, 1997, 1.
[8] Christopher Saricks, Michael Wang and May Wu, "Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn" Argonne National Laboratory, 1997, 4.
[9] Christopher Saricks, Michael Wang and May Wu, "Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn" Argonne National Laboratory, 1997, 5.

positive elements of corn ethanol illustrated by the above source, a scientist with experience at Cornell University counters that corn ethanol cannot be considered a green and renewable fuel source.[10]

An article by Tad W. Patzek titled *A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle* provides discourse for energy required in the production of ethanol. In his abstract, Patzek notes that corn ethanol is "two to four times less favorable than production of gasoline from petroleum."[11] The author notes that "because corn grain is a nascent or baby fossil fuel, it takes a lot of energy to transform it into ethanol."[12] To provide evidence for his claim, Patzek illustrates that an average bushel of corn yields just shy of 2.7 gallons of denatured ethanol. Second: approximately thirty-four thousand BTUs of natural gas are used in ethanol refinement. Additionally, Patzek also explained that about .75 kilowatts per hour of electricity are needed to turn corn to fuel.[13] The author also expounds that the most efficient refinery included in his study found energy use in the refining of corn ethanol to equated to approximately fifty-eight percent of the value of ethanol. In other words, refinement of the ethanol reduced the net energy yield per gallon of corn ethanol to forty-two percent. Further, Patzek notes that about five times more energy is required to refine ethanol than is needed in the refining of petroleum-based automobile fuels (gasoline and diesel). While the point of this chapter is not intended to favor petroleum as a fuel source, it is beneficial to compare the efficiency of

[10] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 127.
[11] Tad W. Patzek "A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle" Natural Resources Research Vol 15, No 4, 2006, 268.
[12] Tad W. Patzek "A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle" Natural Resources Research Vol 15, No 4, 2006, 256.
[13] Tad W. Patzek "A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle" Natural Resources Research Vol 15, No 4, 2006, 257.

the fuels to determine credibility of the renewability claims regarding ethanol fuel. Thus, observing the above data is important to the construct of the paper because gaining an understanding of approximate energy required in the refinement of corn ethanol provides for deeper analysis regarding the efficiency of corn as a fuel source.

Patzek noted that analysis of the “corn-ethanol cycle” is best considered while keeping both the (law of energy and conservation) and the (law of mass conservation) in mind.[14] Patzek argues that from the planting stage to the local fuel station, production of corn ethanol requires a considerable amount of energy and resources. In addition, fossil fuels need to be conserved in order to allow “our civilization to survive a little longer.”[15] Patzek closes his analysis by asking “at what level should we (the U.S.) be producing biofuels?”[16] The author noted that production of the fuel needs to be implemented at some level. However, unless ease of practically farming crops other than corn; an example being switchgrass or other cellulosic biomass ethanol should only be implemented at a limited capacity.

A scientist who taught at Cornell University adds to the argument that corn ethanol poses a negative energy balance is in his source *Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are negative*. David Pimentel boldly claims that corn ethanol requires about twenty-nine percent more energy to produce a unit of corn ethanol than the unit of ethanol contains. Pimentel explains that the United States Department of Agriculture is a considerable supporter of corn ethanol and scientific

[14] Tad W. Patzek “A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle” Natural Resources Research Vol 15, No 4, 2006, 259.
[15] Tad W. Patzek “A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle” Natural Resources Research Vol 15, No 4, 2006, 264.
[16] Tad W. Patzek “A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle” Natural Resources Research Vol 15, No 4, 2006, 268.

research regarding the fuel source. It is important to consider that much of the research that prompted research in the article *Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn* was inspired by the USDA. In addition, Pimentel identifies large corporations who are in the business of profiting on commodities such as bulk grains like soybeans, and relevant to this research, corn. Dr. Pimentel explicitly identified the company Archer Daniel Midland (also known as ADM) as an industry with motive to support corn ethanol in the United States.

To establish a baseline, Pimentel begins explaining his analysis of corn ethanol by giving an approximate amount of fuel that a refined corn is equivalent to. Pimentel adds that approximately five gallons of ethanol are derivable of two bushels of corn when using "large plants."[17] To quantify, a bushel of corn is further equivalent on average to fifty-six pounds. Thus, according to Pimentel's research, over fifty-five pounds of corn are needed to produce two and a half gallons of ethanol. Establishing a mental image of these data makes tangible the amount of corn needed to practically produce corn ethanol. In addition, Pimental's article *Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative*, published in 2003, notes that an average acre of corn will yield approximately three hundred forty gallons of ethanol. While three-hundred forty gallons may appear to be a relatively substantial amount, consideration of the energy necessary to grow, harvest, market and refine those three-hundred forty gallons of corn ethanol illuminates the efficiency of this fuel source differently. On average, a hectare of corn (2.47 acres) yields eight thousand five hundred ninety kilograms of corn. Following the refining phase, such an amount only translates to eight

[17] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 128.

hundred forty-two gallons of ethanol. More importantly, according to Pimentel, the above eight hundred forty-two gallons of ethanol requires about 33.9 million BTUs (a heat/energy designation also known as a British Thermal Unit) in the farming and refining of corn into fuel.

Pimentel accounts for: diesel, gasoline, nitrogen, phosphorus, potassium, lime, seeds, herbicide, insecticide, electricity as well as other assets with energy value as necessary to both, effectively and efficiently produce ethanol. Diesel is used in farm machinery due to its' superior performance in high torque applications such as tilling soil on uneven and shifty terrain. Farm equipment almost exclusively implement diesel fuel in quest of efficient operation.

Nitrogen, phosphorus, potassium and lime are used to fertilize, and/or improve soil condition for crops (corn in this case) to boost yield. Fertilizer could be removed from this research because it is not required to grow plants. However, reduced yield would ultimately lead to a need to sow considerably more land in ethanol crops. In turn, one can infer that planting and tending more cropland not only encroaches on additional ecosystems but would also make a need for more diesel to be used in the planting and harvesting phases. To counter, one can argue that diesel use would be similar in both cases due to not using the fuel in the application of fertilizer. Next, Pimentel also considered energy value of insecticide and herbicide. Like fertilizers, herbicide and insecticide are not necessary to grow a crop. However, herbicide mitigates lower crop yield on basis of removing weeds and other unwanted vegetation that would compete with the desired crop for water and nutrients within the soil. Likewise, insecticide mitigates lower yield by preventing insects or deleterious pests from consuming the crop.

While, insecticide and herbicide generally do not equate to a large value of energy, they do hold some (herbicide more so than insecticide). Lastly, both electricity and gasoline are required in the refining process of ethanol. Key takeaways from this analysis lend to further discourse regarding corn ethanol and the consideration thereof as a green or renewable fuel source. Diesel fuel, like gasoline is a petroleum-based product. However, as illustrated in the above discourse, large amounts of this non-renewable fuel source are being used to produce a fuel source that is ironically considered by some to be green and renewable. To add, the gasoline necessary to refine the fuel source in non-renewable as well.

One may surmise that even if ethanol is less renewable than full-fledged petroleum fuel products, the utilization of fewer unrenewable sources is still worth federally subsidizing ethanol production. However, the flaw in such logic lies within the energy balance of corn ethanol production. For example, David Pimentel added up approximate energy amounts in BTUs from the assets mentioned in above paragraphs. Pimentel found that approximately 99 thousand BTUs of energy are used in the production of a gallon of ethanol from the planting to the refinement of the fuel source.[18] In contrast, a gallon of ethanol contains 77 thousand BTUs of energy.[19] Thus, Pimentel claims that "about twenty-nine percent more energy is required to produce a gallon of ethanol than the energy that is actually is in ethanol."[20] Additionally, Pimentel neglected

[18] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 128.
[19] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 128.
[20] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 128.

to include energy use in the transportation of ethanol from refineries to fueling stations or other respective.

Pimentel adds in his analysis that ethanol may be more renewable and efficient when using corn biproducts for the manufacture of ethanol. Biproducts of corn such as distillers dried grains is a high value foodstuff used to feed cattle and supplement other ruminants for show performance. For Example, distillers dried grains generally contain a protein value between twenty-five and thirty percent. In addition, distillers dried grains have a fat percentage of approximately ten percent. In comparison to other foodstuffs, the mentioned nutritional benefits relative to distillers dried grains are considerably high. However, the nutritional advantages of distiller grains are contrasted by low palatability. Due to low palatability of distillers dried grains, the foodstuff is used more as a supplement than a base ration compounded with high availability the product due to large quantities of corn crops in the United States lend such a resource relatively abundant for ethanol production. Pimentel notes that the use of this source for fuel lends to more efficiency of the corn plant. For example, the scientist adds that using distillers dried grains as a fuel source can reduce "the negative energy balance for ethanol from twenty-nine to twenty percent" thus, not bringing the fuel source to a positive energy output, but at least improving the efficiency by nine percent.[21] It is important to note that the source *Fuel-Cycle Fossil Energy Use and Greenhouse Gas Emissions of Fuel Ethanol Produced from U.S. Midwest Corn* referred to above used distillers dried grains in the article for projecting corn for fuel in a more positive manor than Pimentel does in his source. However, as countered above, harvesting chaff and other corn biproducts beyond those

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[21] David Pimental, "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative" Natural Resources Research, Vol 12, No 2, 2003, 130.

accumulated in refinement processes can lead to accelerated erosion and nutritional loss of tillable soil. Pimentel adds that some members of the United States Department of Agriculture is overly optimistic in their claims regarding the effectiveness of ethanol as a fuel source. The motive to move the social and capital construct regarding fuel sources in the United States away from dependence on Middle Eastern oil and toward domestic energy may be more evident than the smokescreen goal of attempting to improve the environment.

1.3: Post-Refinement Efficiency of Ethanol

Now that we have investigated the negative energy balance relevant in the realm of corn ethanol, it is prudent to also consider the viability of ethanol after refinement. For such discourse, we will investigate an experiment conducted by Edmunds in 2009 that compares efficiency and greenhouse gas emissions between E-85 (fuel blend containing up to eighty-five percent ethanol) and gasoline. The website article titled *E85 vs. Gasoline Comparison Test* by Dan Edmunds asks "should America bet the farm on ethanol?"[22] To answer the question as Dan Edmunds best saw fit, the experiment utilized a 2007 Chevrolet Tahoe for testing. Edmunds' crew mapped out a trip from San Diego to Los Vegas and back. For the round trip, the overall distance was approximately six hundred and sixty-seven miles. The crew made two trips. Regular E-15 gasoline (fifteen percent ethanol) provided the energy needed to facilitate the first trip. Then, the crew drained the tank of gasoline, and ran a round trip on E-85 on the following day. The crew used the same fuel pumps on both trips to get a more precise assessment of the amount of fuel used. On the E-15 tank, the crew set the Tahoe on cruise control at seventy-five

[22] Dan Edmunds, "E85 vs. Gasoline Comparison Test" Edmunds. https://www.edmunds.com/fuel-economy/e85-vs-gasoline-comparison-test.html (accessed April 30, 2021).

miles per hour where applicable. In the end, the Tahoe burned fifty gallons of E-85 on a round trip.[23] On the other hand, the Chevy used about thirty-six and a half gallons on regular E-15 gasoline.[24] In other terms, the E-85 ran on thirteen and a half miles to the gallon vs. over eighteen miles to the gallon on E-15.

In addition to a fuel efficiency test, Edmunds' crew also tested the amount of Greenhouse gas emissions (carbon dioxide in this case) released into the atmosphere. Gaining an understanding of differences (if any) regarding greenhouse gas emissions of the two fuels (ethanol and gasoline) is critical to determining truthfulness of ethanol and claims to its renewability. On the same round trip from San Diego to Los Vegas and back, Dan Edmunds tested pounds of carbon dioxide released from the E-15 mostly gasoline blend in contrast with the majority ethanol, E-85 blend. Edmunds crew found that the round trip on gasoline emitted approximately seven-hundred seven pounds of carbon dioxide pollution. On the other hand, the tank of E-85 produced seven-hundred and three pounds of carbon dioxide emissions.[25] Thus, at face value, ethanol took a slight advantage in terms of emitting less air pollution. The difference was roughly four pounds less carbon dioxide when burning E-85. However, as stated above, net energy balance can be overlooked when determining efficiency, practicality, and renewability of corn ethanol. As a disclaimer, Edmunds adds that his experiment was not intended to ultimately answer questions regarding the energy viability of ethanol. The source lacks due to reflecting on an experiment that only tested a single vehicle on the two fuels a

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[23] Dan Edmunds, "E85 vs. Gasoline Comparison Test" Edmunds. https://www.edmunds.com/fuel-economy/e85-vs-gasoline-comparison-test.html (accessed April 30, 2021).
[24] Dan Edmunds, "E85 vs. Gasoline Comparison Test" Edmunds. https://www.edmunds.com/fuel-economy/e85-vs-gasoline-comparison-test.html (accessed April 30, 2021).
[25] Dan Edmunds, "E85 vs. Gasoline Comparison Test" Edmunds. https://www.edmunds.com/fuel-economy/e85-vs-gasoline-comparison-test.html (accessed April 30, 2021).

single time. However, the source does allow us to infer that carbon dioxide or smog coming out of a motor burning ethanol is not going to be radically better for the health of our atmosphere (if at all) than fuels that use a higher ratio of petroleum. Furthermore, it is important to note that the results of Edmunds's experiment do little to illustrate greenhouse gas emissions released when accounting for the net energy balance relative to corn ethanol. For example, if a considerably larger amount of petroleum energy is required to produce (plant, harvest and refine) corn ethanol than to produce sources of fuel like gasoline, the actual production of carbon dioxide could be much more in the case of corn ethanol. The realization mentioned in the last sentence is an important and interesting concept to consider. First, the idea that more carbon dioxide is produced when burning corn ethanol rather than petroleum is important because it challenges one of the most widely understood positive tenets of the fuel source. Furthermore, the claim is interesting because if true, most of those who burn ethanol to mitigate global warming and negative environmental impacts may in contrast, be dealing the most environmental harm.

1.4: More on Carbon Dioxide

One of the many vital roles that plants play in the construct of a healthy planet includes carbon intake. Carbon dioxide can help warm the planet. However, since carbon dioxide, (a greenhouse gas) is emitted into the atmosphere by means that include combustion of fuel, hence the relevance of exhaust emissions in the determination of environmentally friendly fuels. Scholars credit overabundance of greenhouse gasses as a cause of global warming. Plants are necessary for mitigating carbon dioxide levels in the atmosphere through their absorption of the gas for photosynthesis. Further, crops, forests and various other plants put unused carbon down into the soil. This removal of carbon dioxide from the atmosphere is known as carbon sequestration. However, some crops emit carbon back into the atmosphere at greater rates than other crops when cultivated/tilled. Tilling of soil generally can lent to the release of up to, or over a fifty percent "loss in carbon soil."[26] Thus, taking consideration of carbon remission into the atmosphere is relevant in the analysis of how effective ethanol crops are regarding the claim of renewability due to emitting fewer greenhouse gas emissions than petroleum. Furthermore, analyzing carbon remission due to cultivation is important because it supports trends of no-till farming.

One study conducted in Brazil compared different crops in terms of their abilities in remitting carbon into the atmosphere through the production phase of ethanol. The study titled *Carbon footprint in the ethanol feedstocks cultivation – Agricultural CO2 emission assessment* pits the carbon sequestration effectiveness and ecological footprint of rice, cassava, sugar beet, sugar cane, and corn crops against one another.[27] In short, the corn and sugar beet crops were the most effective at carbon sequestration and keeping a higher percentage of carbon down into the soil upon tillage and cultivation. However, we should consider that corn is the only crop of the five studied in the article that is grown in the United States at a large rate. Compatibility of most climates in the U.S. cater to corn crops at a much greater rate than the other crops mentioned in the article. A publication from 2009 titled *Estimating life cycle greenhouse gas emissions from corn-ethanol: a*

[26] Izabel C. Zattar, Karina S. Machado, Marcell M.C. Maceno, Robson Seleme. "Carbon footprint in the ethanol feedstocks cultivation – Agricultural CO2 emission assessment" Agricultural Systems 157, 2017, 142.
[27] Izabel C. Zattar, Karina S. Machado, Marcell M.C. Maceno, Robson Seleme. "Carbon footprint in the ethanol feedstocks cultivation – Agricultural CO2 emission assessment" Agricultural Systems 157, 2017, 144.

critical review of current U.S. practices adds that natural emissions such as carbon remission from the soil are much more difficult to determine than so for exhaust and industrial emissions.[28] Thus, concrete conclusions in the analysis of carbon sequestration and remission findings should be taken with a grain of salt. Nonetheless, the above analysis illustrates that corn-based fuel is more ecologically friendly than some sources.

1.5: The Octane Rebuttal

Ethanol rich fuel generally contains greater levels of octane than pure gasoline. Some mistake the idea of higher energy fuels with higher octane fuels. Even fueling stations propagate this skewed thought through advertising. For example, low octane fuel (generally with less ethanol) like 87 octane rating pump gas are often dubbed "regular" or "unleaded" because they have a lower octane rating than the higher octane rated 89 and 93 "Super" and "Premium" blends of fuel. Higher octane fuels are used in performance vehicles like race cars because the timing of fuel ignition is much more precise than on low octane fuels like unleaded. Using less precise and more combustible octane ratings like 87 can damage high compression engines. Thus, the reason that higher octane (higher ethanol) fuel blends are used in racing applications, is because the motors used have a much higher compression ratio. Less stable low octane fuel occasionally detonates before the intended ignition due to the heat of the hot combustion chamber compounded with the pressure of the cylinder violently forcing the fuel and air (oxygen) mixture up into the combustion chamber. Pre-ignition due to unstable fuel is called detonation. However, the counterargument regarding greater fuel efficiency in the subject of ethanol is relevant in motors of high compression ratios. While examples above illustrate that

[28] Alissa Kendall and Brenda Chang. "Estimating life cycle greenhouse gas emissions from corn-ethanol: a critical review of current U.S. practices" Journal of Cleaner Production 17, 2009, 1176.

corn-based biofuel is inefficient due to a negative net energy balance, it should be noted that high compression engines generally yield better fuel efficiency on ethanol than lower compression engines do on higher percentage gasoline blends. However, the efficiency advantages of using ethanol fuels in high compression engines do not outweigh the energy lost in production of corn ethanol.

C. Ford Runge argues that proponents of bumping the common E10 (ten percent ethanol to gasoline ratio) to thirty percent ethanol would be made more practical to higher compression engines. Runge further adds that such compression ratios in engines would be "more akin to racecars."[29] The importance of Runge's claim is relevant in the technological advance of modern automobiles. While most of this paper will illustrate environmental deficiencies of corn ethanol, technological advances in internal combustion engines may favorably set conditions for the advent of a more practical fuel source in the future. Additionally, supporters of federally mandating higher percentage of ethanol blends like E30 argue that the need to infuse gasoline with octane additives would be mitigated. Furthermore, less octane boosters in fuel might on the same note equate to fewer deleterious effects on health by dangerous aromatic hydrocarbons.[30]

1.6: Chapter Takeaways

The prior two subsections of this chapter illustrate some advantages of the corn-based fuel source. Advantages demonstrated that corn has a propensity to yield a better ratio of carbon sequestration than fuel sources like rice, casava and sugar cane.

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[29] C. Ford Runge, "The Case Against More Ethanol: It's Simply Bad for Environment" Yale Environment 360. https://e360.yale.edu/features/the_case_against_ethanol_bad_for_environment (Accessed April 26, 2021).

[30] C. Ford Runge, "The Case Against More Ethanol: It's Simply Bad for Environment" Yale Environment 360. https://e360.yale.edu/features/the_case_against_ethanol_bad_for_environment (Accessed April 26, 2021).

Additionally, ignition of ethanol rich blends is more precise than ignition of conventional gasoline. However, as mentioned in the respective subsection, octane levels generally do not correlate with greater energy return. Furthermore, this chapter demonstrates that claims of practicality and renewability of corn ethanol are uncredible. The added erosion of cropland in the attempted meeting of the demand of fuel in the U.S. counters claims of ecosystem benefit by illustrating a decline in soil health. Additionally, the multiple assets required in production of corn-based ethanol illuminate false viability as a renewable fuel source due to a negative energy balance.

Chapter 2: The Impact of Corn Ethanol on the Water Network

This chapter will discuss the relationship between the water supply and corn ethanol in six sections. Sections discuss environmental impacts on the water network by investigating water use for crop growth. Furthermore, the chapter incorporates claims by an environmental researcher, Emily Cassidy. The chapter builds off her input by discussing the effects of nitrogen and potassium on drinking water and surface water. Then a closing section follows impacts of oil spills and provide analysis to debate environmental, impacts of ethanol regarding the water network.

2.1: Irrigation

In 2009, an article published by Kevin R. Fingerman, Margaret S. Torn, Michael H. O'Hare and Daniel M. Kammen researched water usage needed to grow crops. Their article *Accounting for the water impacts of ethanol production* used the state of California for their study. The researchers investigated farmland in each county of the state. Most crops that they researched were "low value crops." Low value crops include common crops such as corn, wheat, rice, sorghum, barley, oats, among other varieties. The researchers especially studied corn, sugar beet and miscanthus crops because these are sought after for ethanol production. On an environmentally positive note for ethanol production, water use for refining only equated to one percent of the amount used in the life cycle of these crops. While this seems to agree with the environmentally friendly sentiments that corn ethanol has, water use in earlier phases of crops' life cycles are less renewable. Depending on the county, the researchers showed that between

500 to 3,500 liters of fresh water were needed to irrigate corn and other ethanol crops in order to produce a single litter of ethanol. In contrast, the authors found that oil produced from tar sands require roughly fourteen liters of water to refine a liter of fossil fuel. And furthermore, the authors recorded that only a little over two liters of water were necessary to refine and produce good crude oil into a liter of gasoline.[31]

The researchers noted that making inferences off of these data to assume that producing petroleum fuel is one hundred or more times more water efficient than corn ethanol is "overly simplistic."[32] However, in the best-case scenario, growing crops for fuel is obviously less water efficient than producing fossil fuel. The authors added that growing crops for fuel would likely put less stress on the water table if they were grown in regions of high rainfall. While irrigated corn production was very good in the hot southern counties of California, those more arid counties required an exponentially greater amount of water to grow crops than is necessary in the more temperate counties. This is evidence that fuel production from ethanol is least renewable in dry regions. The authors wrote that the demand for fresh water in California was at seventy percent when this article was published in 2009. However, that amount is projected to increase to ninety percent at forty years from now. Also, this study provides evidence that growing crops for fuel is not as environmentally friendly as proponents may believe.[33] The article projected that demand for water is likely to increase from seventy to ninety percent in fifty years from when this article was submitted for publication in 2009. This shows that

[31] Kevin R, Fingerman, Margaret S, Torn, Michael H, O'Hare, Daniel M, Kammen, "Accounting for the Water Impacts of Ethanol Production," Environmental Research Letters," 2010, 5.
[32] Kevin R, Fingerman, Margaret S, Torn, Michael H, O'Hare, Daniel M, Kammen, "Accounting for the Water Impacts of Ethanol Production," Environmental Research Letters," 2010, 5.
[33] Kevin R, Fingerman, Margaret S, Torn, Michael H, O'Hare, Daniel M, Kammen, "Accounting for the Water Impacts of Ethanol Production," Environmental Research Letters," 2010, 6.

the issue of watering crops is probably not going away unless attempts are taken to counteract the growing water table deficit.

Similar research was conducted in collaboration of Sandia National Laboratories with the General Motors' Global Energy Systems team. Research intended to model and determine the amount of water used for irrigating ethanol sources through 2030. The researchers inferred based on trends in 2008 that ethanol production in the United States would be at approximately 90 billion gallons in 2030.[34] Ethanol production in the U.S. was at roughly 15 billion gallons in 2019, thus the team might have overestimated the future amount of ethanol production in the United States. Nonetheless, this source provides beneficial insight that can contribute to discovering the practicality of ethanol in its interaction with the environment. According to their research, farmers in 2006 used an average of 5,616 million gallons of water each day to irrigate biofuel crops.[35] They projected that the number would grow to over 11,500 million gallons of water use a day to irrigate biofuel crops by the year 2030.[36] Interestingly, the study found that irrigation water in 2006 only represented approximately one percent of water use in the United States. However, the paper notes that water consumption numbers regarding irrigation contrast the seemingly lower percentage of water use. Of water in 2006, approximately seventy-eight percent was consumed through irrigation.[37] Used water represents the amount of extracted from a source. Consumed water is water lost through evaporation or harvested plants. This is an important point to the chapter because it illustrates that water for irrigation takes a significantly longer amount of time to return and recharge water

[34] Amy C, Sun, Len Malczynski, Vince Tidwell, "Biofuel Impacts on Water," Sandia Report, 2011, 3.
[35] Amy C, Sun, Len Malczynski, Vince Tidwell, "Biofuel Impacts on Water," Sandia Report, 2011, 13.
[36] Amy C, Sun, Len Malczynski, Vince Tidwell, "Biofuel Impacts on Water," Sandia Report, 2011, 17.
[37] Amy C, Sun, Len Malczynski, Vince Tidwell, "Biofuel Impacts on Water," Sandia Report, 2011, 18.

sources (for the water that does) than used water. Thus, crop irrigation strongly illustrates the largest contributor of freshwater loss in the United States. The study adds that water consumption by irrigation correlates the strongest in western states and in the High Plains. This adds credibility to the above source *Accounting for the Water Impacts of Ethanol Production*.

2.2: Health and Economic Impacts of Contaminated Groundwater

To move on, this chapter will cover some of the perceived impacts corn ethanol has relative to water. A writer for the Environmental Working Group, Emily Cassidy noted that legislation such as the EPA supported Energy Independence and Security Act of 2007 which favors expanse of corn ethanol is in contradiction with the Safe Drinking Water Act. She notes that extended incentives to plant and harvest corn for ethanol has led to the tilling of Midwestern prairie and grasslands. This facilitates the release of carbon from the soil. Tilled soil and added erosion can affect the efficiency of waterways and streams. She adds that nitrogen fertilizers necessary to make high yield farming possible and practical can contaminate water sources. She also mentions that fertilizers can facilitate destruction of near shore underwater ecosystems. Runoff of fertilizers can cause the large-scale algae blooms that we face today. Such examples include the ones commonly evident in the Gulf of Mexico. In Iowa at the time that this article was written in 2016, Cassidy noted that Des Moines Water Works was amidst a lawsuit with counties upstream of the city for the mass nitrate pollution evident in waterways. Nitrates in the water can cause water to be too toxic to safely consume. Cassidy argued that high level nitrates in drinking water can cause cancer and blue baby syndrome. She noted that the Safe Drinking Water Act mandates that a liter of water must not contain more than 10 milligrams of nitrates.[38] Cassidy wrote that Des Moines Water Works has been forced to filter out nitrates at an increasing rate. In 2015, the nitrate removal facility needed to be used 177 days that year.[39] During that time, nitrate filtration alone, costed 1.5 million dollars.[40] This led to an increase of utility cost for the public. This paints a noticeable contradiction between the goals of environmental protection by the EPA expressed for the Energy Independence and Security Act of 2007, and the effects this act is having on the water supply. The act is causing farmers to pursue corn growth for ethanol. In effect, polluted water conflicts with the goals of the Safe Water Act, which is also supported by the EPA.

To add, an article *Too Much of a Good Thing? Nitrate from Nitrogen Fertilizers and Cancer explained* that there could be a link between nitrates for fertilizing crops, the water supply and human health issues. The article notes that about 90% of the rural population in the U.S. utilizes groundwater for drinking. The article claims that groundwater under fertilized cropland can be "several to a hundred-fold higher than levels under natural vegetation."[41] This paper noted that a study completed in 1992 showed that nine percent of rural water wells had higher than suggested nitrate levels. The article says that there are at least three common nitrate related health effects. First, ingested nitrates can inhibit the oxygen level in the blood. This can cause baby blue

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[38] Emily Cassidy, "More Ethanol Means More Toxic Water Pollution" Environmental Working Group. https://www.ewg.org/news-insights/news/more-ethanol-means-more-toxic-water-pollution (Accessed February 05, 2020).
[39] Emily Cassidy, "More Ethanol Means More Toxic Water Pollution" Environmental Working Group. https://www.ewg.org/news-insights/news/more-ethanol-means-more-toxic-water-pollution (Accessed February 05, 2020).
[40] Emily Cassidy, "More Ethanol Means More Toxic Water Pollution" Environmental Working Group. https://www.ewg.org/news-insights/news/more-ethanol-means-more-toxic-water-pollution (Accessed February 05, 2020).
[41] Mary H, Ward, "Too Much of a Good Thing? Nitrate from Nitrogen Fertilizers and Cancer," Reviews on Environmental Health Vol 24, No 4, 2008, 1.

syndrome and deformities in infants. Secondly, the article notes that nitrates can become like carcinogens. Also, the authors noted that high nitrate levels can affect thyroids and inhibit iodine uptake. This can raise cancer susceptibility. The journal argues that there are at least small correlations between high nitrate water and colon, kidney, and non-Hodgkin lymphoma cancers.[42] Also, a study showed that high nitrates can lead to rectal cancer. The paper noted that researching correlations between disease rates and nitrogen contaminated water is difficult because nitrogen contamination largely impacts those who have private wells in rural locations.

Researchers Stuart Halliday and Mary Wolfe used geographic information systems to detect the types of crops and fertilizer/pesticide amounts that were spread in Texas. By understanding the suggested levels of fertilizers per crop, the systems can be used to illustrate a potential degree of aquifer pollution. Research conducted in *Assessing Ground Water Pollution Potential From Nitrogen Fertilizer Using A Geographic Information System* suggests that rocky counties in west Texas and heavily forested counties in the east had least chance of groundwater pollution. The findings make sense because the lowest percentage of Texas crops are planted in those regions. According to the research, fifty-three percent of Texas aquifers fell into moderate potential contamination locations. Twenty-four percent of the aquifers fell into the high category of potential pollution. Areas at threat of high pollution are largely located in east-central Texas. Moderately polluted locations are represented by most of the cropland from Austin to Midland area, and into the northern panhandle. Furthermore, the paper revealed that in 1988, seventy-eight percent of groundwater used in that year was utilized for

[42] Mary H, Ward, “Too Much of a Good Thing? Nitrate from Nitrogen Fertilizers and Cancer,” Reviews on Environmental Health Vol 24, No 4, 2008, 3.

irrigation. This study contributes to this thesis because it provides evidence that regions with more crops also contain more nitrates in the ground water. Furthermore, this paper was published in 1991. Thus, we can infer that nitrates can damage groundwater quicker than some might imagine and are likely to be at higher levels today. Finally, their research also illustrated the level of groundwater that was being utilized to irrigate Texas crops.[43]

2.3: Economic, Health and Environmental Impacts of Rivers and Offshore Water

So far, we have investigated effects of corn ethanol and the relation between it, consumption of ground water and human health. Now we will observe farming effects on offshore water. This section continues to illustrate the environmental effects of corn ethanol on basis of health and economic impacts. However, this section will specifically illustrate algae blooms, and how they impact both ecosystems and the economies of certain communities.

According to a journal by the European Commission, harmful algae blooms are negatively shown to effect human health (as already noted), the fishing community, recreational activities, and management costs. The journal noted that the most notable human health impacts caused by algae blooms include: Amnesic Shellfish Poisoning, Paralytic Shellfish Poisoning, Diarrheic Shellfish Poisoning, Neurotoxic Shellfish Poisoning and Ciguatera Fish Poisoning. In addition to non Hodgon Lymphoma and Baby Blue Syndrome, this demonstrates health effects of corn ethanol derived in offshore water as well as the effects discussed in earlier sections. One of the most effective

[43] Stuart L. Halliday and Mary Leigh Wolfe, "ASSESSING GROUND WATER POLLUTION POTENTIAL FROM NITROGEN FERTILIZER USING A GEOGRAPHIC INFORMATION SYSTEM," Journal of the American Water Resources Association, Vol 27, No 2, 1991, 244.

ways to correlate human diseases and algae blooms is by monitoring the frequency of medical needs and during algae blooms. According to one article referenced in the journal, the estimated annual economic losses in Canada due to some of the above diseases equate to about 670 thousand dollars. According to other articles referring to the United States, as much as 350 million dollars are annually lost due to pathogens, marine toxins, and seafood-borne diseases.[44] Furthermore, fish mortality in the wake of harmful algae blooms is shown to impact commercial fishing and the livelihood and jobs of workers for commercial fishing. This journal illustrates many staggering examples of the impacts that the seafood business has taken due to harmful algae blooms. One example illustrates the losses regarding mussels in the New England area during the 2005 red tide. Losses were estimated at 400 thousand dollars in the mussel industry. During the 2011 oyster season, some harvesting locations were closed by the Texas coast. In just 3 months, the average fishing captain experienced losses of eight thousand five hundred dollars and over five thousand and five hundred dollars per deckhand.[45]

The data illustrate a direct correlation between algae blooms and negative financial impacts by private individuals. Among the economic impacts of the sea harvest industry and human health effects, harmful algae blooms also effect the restaurants and water recreation communities. According to the article, two red tide events between 1995 and 1999 negatively impacted restaurant and lodging business offshore of north western Florida. The affects were illustrated by losses of over $2.8 million per month.[46] These

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[44] Diana Conduto, Isabella Sanseverino, Luca Pozzoli, Srdan Dobricic and Teresa Lettieri., "Algal Bloom and Its Economic Impact," European Commission, Joint Reseach Center, 2016, 24.
[45] Diana Conduto, Isabella Sanseverino, Luca Pozzoli, Srdan Dobricic and Teresa Lettieri., "Algal Bloom and Its Economic Impact," European Commission, Joint Reseach Center, 2016, 27.
[46] Diana Conduto, Isabella Sanseverino, Luca Pozzoli, Srdan Dobricic and Teresa Lettieri., "Algal Bloom and Its Economic Impact," European Commission, Joint Reseach Center, 2016, 30.

losses compounded with the tax dollars that were needed to ensure public safety regarding contaminated seafood and monitoring of the shores demonstrated unfortunate effects of algae blooms.[47]

This source helps to add credibility to the claims by Emily Cassidy noted earlier in the chapter by illustrating health impacts of large-scale crop farming. To add to our information regarding toxic algae blooms in the Gulf of Mexico and its relationship with nitrogen runoff from fertilizers, it will be beneficial to incorporate a study by Simon Donner and Christopher Kucharik. Their study investigated nitrogen levels in the Mississippi-Atchafalya River system. This research was largely motivated by the increasing occurrences of dead zones in the Gulf of Mexico. The authors revealed that the dead zones recent to the publishing year of the article (2008) were growing over the 20 thousand square kilometer mark.[48] The authors also found that the hypoxia and dead zones from fertilizer runoff were contributing to "benthic mortality" of fish species which in turn is economically antagonizing fisheries.[49] The study explained that DIN (dissolved organic nitrogen) leaching is most notable in the humid parts of the corn belt. Mainly the Ohio, Illinois, and Indiana area are among the highly affected regions. At the time of its publication, this study ultimately found that DIN export would likely continue to grow to over forty percent the federal maximum target level of hypoxia by the year 2022.[50] The

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[47] Diana Conduto, Isabella Sanseverino, Luca Pozzoli, Srdan Dobricic and Teresa Lettieri., "Algal Bloom and Its Economic Impact," European Commission, Joint Reseach Center, 2016, 30.

[48] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4513.

[49] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4513.

[50] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4517.

study illustrates that federal environmental legislation, and the 2005 Energy Policy Act are conflicting with each other. To add, the study further noted that lowering and meeting the federal hypoxia level while increasing crop growth for fuel would be "practically impossible" given current trends of farming.[51] The authors wrote that radical changes in "feed production, diet, and agricultural management" would need to take place in order to meet that goal.[52] Rather, the authors noted that there is a high likelihood that the "mean annual nitrogen export level" will lead to extensive hypoxia in the Gulf of Mexico by 2022.[53] This study demonstrates the extent that water pollution is correlated with federal goals of increasing ethanol production. An article in *the Journal of Environmental Quality* called The New Gold Rush: Fueling Ethanol Production While Protecting Water Quality, adds to this discussion of corn ethanol and how its' use impacts networks of the environment. Regarding nitrogen fertilizers, this research paper notes that corn is "inherently inefficient" in nitrogen uptake. The article proposes that corn crops often fail to utilize forty to sixty percent of the nitrogen used to fertilize them. In addition to inefficiency, remaining nitrogen has the potential to leach into the soil and pollute water sources. Interestingly, the article also explains that a by-product of corn ethanol production, known as distillers dried grains, can facilitate contaminated runoff. Distillers dried grains are a high protein and fat resource for livestock feed. Due to the high rate of

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[51] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4517.
[52] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4517.
[53] Christopher j, Kucharik and Simon D, Donner, "Corn-Based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," Proceedings of the National Academy of Sciences of the United States of America, Vol 105, No 11, 2008, 4517.

corn ethanol production, these foodstuffs are inexpensive. Thus, commercial livestock producers and feedlots readily utilize the source for feeding. While this is positive for commercial meat and dairy farmers, distillers dried grains contain high levels of potassium. Thus, animals that are fed distillers dried grains pass high levels of potassium through their waste. According to the article, supplementing livestock diets to equal a ration of just 20 percent distillers dried grains can increase potassium use from the recommended 0.35 percent to 0.5 percent. Like nitrogen, run-off potassium also contributes to eutrophication and harmful algal blooms. This is another example of corn ethanol production and use indirectly leading to water pollution.[54]

2.4: Algal Blooms vs. Oil Spills

Now that we have visited some problems in the water network that are correlated or caused by ethanol use and production, we will look at economic, environmental and health perspectives that are positive for ethanol use (at least instead of petroleum). Harold F. Upton authored *The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry* to explore the impacts of the massive gulf oil spill in 2010. The source included that "over 200 million gallons" were released in the fiasco over a span of 84 days.[55] This led to a maximum area of over thirty-six percent of the Gulf of Mexico, or 88 thousand five hundred twenty-two miles that were federally closed to prevent contaminated seafood from damaging public health.[56] According to the source, crude oil contains polycyclic aromatic hydrocarbons that can taint muscle tissue in marine organisms like

[54] Andrew N. Sharpley, Hans W. Paerl, Kyle R. Mankin, Robert W. Howarth and Thomas W. Simpson, "The New Gold Rush: Fueling Ethanol Production While Protecting Water Quality," Journal of Environmental Quality, Vol 37, No 2, 2008, 320.
[55] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 1.
[56] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 1.

shrimp or fish. Since some hydrocarbons are carcinogenic, the Food and Drug Administration prohibits the sale of seafood that has been exposed to high levels of oil. In 2008, just two years before the spill, commercial fishing catches in the Gulf of Mexico equated to a worth of over 697 million dollars.[57] In addition, the seafood industry provided income for over 213 thousand employees.[58] 2010 harvest records for shrimp reported a decrease twenty-seven percent (nearly 36 million pounds) under the amount caught in 2009.[59] These numbers are important because they illustrate that the spill in the gulf wreaked substantial economic repercussions on the fishing communities. In addition to economic impacts of the spill, the article also reveals that a large portion of the ecosystems were damaged in some way. While it is difficult to ascertain the scope of the ecological damage definitively, we know that one thousand and fifty-three miles along the shoreline of the Gulf of Mexico were swept by oil to the surface of the beeches.[60] Dangers of oil for marine and near shore wildlife largely include stunting of growth and suffocation as a result of oil coverage of the considered species.

These examples contribute to the pro ethanol argument by illustrating at the least, that offshore oil drilling is potentially detrimental to the environment. Furthermore, the Deepwater Horizon spill also shows that petroleum drilling accidents can lead to economic loss and put public health at risk. In response to this example, we ask ourselves, does risk of oil spills like this justify the negative repercussions of using and

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[57] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 2.

[58] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 2.

[59] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 5.

[60] Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Congressional Research Service, 2011, 8.

producing ethanol? Arguments like this should consider multiple factors and networks involved in addition to the scope and size of potential problems that are relevant to each fuel. Ultimately, most of us would prefer to choose a totally different energy source that is void of the negative implications. However, due to the current available sources of practical fuels today, we debate the attributes of fuel from petroleum vs. those of ethanol. Using the context of this chapter, ethanol negatively affects more factors of the water network than petroleum does. First, evidence in the chapter decisively shows that irrigation is the single most cause of water consumption in the United States at over 70 percent of the total amount. Secondly, potassium and nitrogen products to fertilize corn or other vegetative sources for fuel is shown to contaminate groundwater. In addition to the negative health risks of baby blue syndrome and cancer, nitrates are very expensive to filter. Furthermore, the algal blooms that lead to eutrophication and dead zones have similar risks as oil spills regarding public health, economy, and ecosystems. However, while effects of oils spills like the Deepwater Horizon spill risk public health to a nearly equal degree as red tides and algal blooms, oil spills probably negatively impact a larger size and scope of the economy and environment when they happen. The key in this debate is considering the frequency that these events take place. Effects of ethanol production and use impact a much wider range of the water network than oil spills do. In contrast, the size of affected areas relevant when petroleum spills happen is greater. Ultimately, negative impacts of ethanol are more dangerous than petroleum because they happen at a much higher frequency. Sometimes, major red tides occur on a yearly basis. In contrast, small oil spills (of a barrel or so) occur offshore every year, but oil spills like Deepwater Horizon happen very rarely. Furthermore, irrigation use for growing ethanol crops, compounded with nitrate contamination in drinking water demonstrate that ethanol is not a clean, renewable, or environmentally friendly fuel source.

2.5: Chapter Takeaways

In closing, this chapter illustrates that corn ethanol is not as environmentally friendly as proponents of the fuel claim. Section 2.2 of this chapter gave us a glimpse of water use needed to grow high yielding crops. The chapter gave a comparison of water used when refining fossil fuel vs. the amount of water involved in growing and refining vegetation (largely corn for ethanol). In section 2.3 the chapter utilized remarks by a very credible source, Emily Cassidy. Her discourse explains how policy support for corn ethanol ironically counters EPA guidelines and the Safe Drinking Water Act. Cassidy, a now senior technical writer for NASA also added to the section by offering information regarding economic and health impacts relative to corn ethanol and ground water. Section 2.3 expressed how nitrogen fertilizer contaminated water leads to underwater dead zones and causes harmful algal blooms that negatively affect public health, ecosystems and the economic livelihood of fishing communities. Following Cassidy's contributions, section 2.5 utilized the Deepwater Horizon oil spill as an example to show support for ethanol as a fuel source to counter the intent of the paper. After providing discourse explaining the repercussions of the spill, the section analyzed perspectives and illustrated negative impacts relevant to both fuel sources. The section illustrated that large oil spills like Deepwater Horizon have the risk to destroy ecosystems and relative economic networks on a larger scale than red tides and harmful algal blooms. However, due to the wide range of factors effected by irrigation and nitrogen pollution, the corn ethanol industry ultimately provides support for the most detrimental commonly used fuel source in terms of public health, the environment and U.S. economy.

Chapter 3: Corn Ethanol and Political Influence on the Socio-Economic Kaleidoscope

This chapter chiefly discusses three tenets. First: the chapter investigates communities that are positively impacted by the advent of corn ethanol in U.S. public. Positive implications include financial gain through increased demand for corn in addition to federal subsidies directed toward agriculture. In contrast, the second subsection discusses communities that include fishing and hospitality businesses that are affected negatively by algal blooms. Finally, the third subsection provides discourse by illustrating political motive for the construct of ethanol in the United States. The chapter ultimately illuminates that voters in the agricultural community has influenced the support of corn ethanol by the Renewable Fuel Standard.

Chapter 3.1: Corn Ethanol as a Benefactor

A book titled *Corn Ethanol: Who Pays? Who Benefits?* by Ken G. Glozer provides discourse regarding, as the title appropriately indicates, the communities who can financially gain due in part to the construct of corn ethanol in the United States society. Chapter six of the publication *Corn Ethanol: Who Pays? Who Benefits?* grapples with those who benefit from environmental policy that promotes corn ethanol. Glozer opens chapter six by noting that an estimate of 500 billion dollars in U.S. governmental subsidies were projected to give the fuel a leg up in just nine years (2008 to 2017).[61] As one would expect, Glozer notes that corn producers and ethanol refiners benefit from the development of federal policy that favors the implementation of ethanol. In contrast, the

[61] Ken G, Glozer. *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 131.

author of *Corn Ethanol: Who Pays? Who Benefits?* also claims that taxpayers, fuel purchasers and food purchasers "pay" for the implementation of this fuel in American fueling pumps.[62] To put into perspective the amount of people impacted (at least financially) regarding the institution of ethanol fuel in the United States, there were "230 million light-duty vehicles" were on the road. Most of which were "burning ethanol-blended gasoline."[63] In addition, Glozer adds that over 300 million food consumers were in the U.S. that year. Thus, Glozer concludes that approximately two to three hundred million U.S. citizens contribute to the existence of ethanol in the United States by indirectly paying subsidies or do so through a forty-five cent federal tax credit on each gallon of blended gasoline.[64] Providing discourse for the rough estimate of those effected by the implementation of ethanol as a fuel source is important because it helps us to determine a tangible scale in which that U.S. citizens are feeding the ethanol industries.

In general, the advent of corn ethanol financially benefits those who live in the midwestern United States. Glozer identifies more ten states in the corn-belt such as: Ohio, Indiana, Illinois, Wisconsin, Missouri, Iowa, Minnesota, Kansas, Nebraska and South Dakota to include some of the largest benefactors of corn consumption. While this paper focuses on corn derived ethanol, Glozer adds that soybean farmers benefit from influx of federal subsidies relative to the ethanol market as well. Thus, it important to note that Glozer's contribution to this thesis is founded on research that is not specific to the use of corn in ethanol. Glozer states that corn crops are most effective when rotated opposite other crops like soybeans. Certain nutrition and fertilizing qualities in the soil

[62] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 131.
[63] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 132.
[64] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 131.

gain a chance to replenish when not supporting the same crop for an extended period. This is important because it illustrates analysis on soybean farming in Glozer's publication *Corn Ethanol: Who Pays? Who Benefit*s? is to a degree, contingent to corn farming due to the precipitous nature of the two crops. The concentration of ethanol refineries is also in the general area of the ten mid-western states that benefit the most from farming and agricultural subsidies.

Glozer references the Environmental Working Group to note that of both, corn and soybean subsidies, twenty "percent of or more" of the benefactors equated to eighty "percent or more" of the approximate overall subsidy funds.[65] In other words, most of the federal funds were allocated to only about twenty percent of those who received any funding. This is important to add, because it demonstrates that farmers who are supported by the ethanol industry due to federal subsidies might not be reaping as much of a benefit as some might believe. The forty states outside of the ten mid-western "corn-belt" states mentioned above reaped less than twenty percent of the federal subsidies directed for corn and soybean farming in the year 2008. Attention to the last sentence is important because it demonstrates that a select area is federally supported. Thus, one could argue that those outside of the ten mid-western states in consideration are, in one way being discriminated against. For example, according to trends relative to when the publication, *Corn Ethanol: Who Pays? Who Benefits?* was published, Glozer surmised that over eighty-eight billion dollars in federal subsidies were projected to be allocated to corn and soybean farmers between the years of 2008 and 2017.[66] Furthermore, the estimated amount of federal funding in the top ten states equated to an amount over 117 billion

[65] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 138.
[66] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 150.

dollars.[67] In comparison, Glozer's findings also demonstrate that soybean and corn estimates in support of corn and soybean farmers come to figure near 143 billon dollars across the entire United States.[68] To add, 117 billion dollars subtracted from a total approximation of 143 billion dollars comes to number equivalent to about 26 billion dollars. In total, the funding illustrates a stark difference in agricultural funds between some of the corn-belt states and the rest of the United States. Ultimately, analysis in this paragraph demonstrate that those who benefit from ethanol do not apply to the U.S. population as whole.

To add credibility to Glozer's research, a study conducted in 2009 by Nickolas F. Fretes, Richard K. Perrin and Juan Pablo Sesmero titled *Efficiency in Midwest US Corn Ethanol Plants: A Plant Survey* researched ethanol production and refinery employment. The study represented ethanol production in Iowa, Michigan, Wisconsin, S. Dakota, Nebraska, Missouri, and Minnesota. In addition, the article concluded that ethanol production plants in the above states produced approximately "53.1 million gallons of denatured alcohol each year."[69] Knowing the amount of denatured alcohol that the above production facilities produced is helpful to the construct of this paper because we can glean insight regarding the expansion and implementation vegetative based fuel production. Furthermore, the study noted that the production facilities employed just under forty personnel each.[70] Since the overall construct of this paper examines the impacts of ethanol to U.S. livelihood, considering the number of Americans employed is

[67] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 150.
[68] Ken G. Glozer *Corn Ethanol: Who Pays? Who Benefits?* Hoover Institution Press, 2011, 150.
[69] Juan P. Sesmero, Nickolas F. Frentes and Richard K. Perrin "Efficiency in Midwest US corn ethanol plants: A plant survey" Energy Policy 37, 2009, 1309.
[70] Juan P. Sesmero, Nickolas F. Frentes and Richard K. Perrin "Efficiency in Midwest US corn ethanol plants: A plant survey" Energy Policy 37, 2009, 1309.

also important. Further, research demonstrates that ethanol refining plants require on average: thirty-seven cents in production energy per gallon of ethanol.[71] Such costs are derived from electricity, natural gas and various other commodities. In 2009, approximately $0.03 per gallon of refinery profit was derived of government subsidies. However, the article notes that subsidies such as the Federal Small Ethanol Producer Tax Credit. Facilities that produce fewer than sixty million gallons per year were eligible to receive $0.10 per gallon in subsidies on the first 15 million gallons produced. Furthermore, the Volumetric Ethanol Excise Tax Credit aka the (VEETC) offered as much as fifty-one cents in subsidies per ethanol gallon.[72] This development is important to consider because one can argue that cost efficiency a fuel source may not be as pertinent to a businessperson if the commodity is heavily subsidized. Furthermore, if ethanol is subsidized on basis of being a renewable, green and relatively efficient, then it is pertinent that the fuel source in fact, accomplishes these goals of leading a more environmentally safe United States. Awareness that government subsidies have been implemented to push the United States in support of more extensive ethanol use is beneficial to the understanding and construct of this paper. In addition to subsidies, Glozer argues that United States citizens also financially contribute in less noticeable ways. For example, demand raised by the fuel industry, can raise the grain prices of foods, and livestock feed which also impacts the food industry through the sale of meats.

Now that this chapter has discussed an interaction between Midwestern agrarian communities and political support relative to biofuel, we will analyze livelihoods that are

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[71] Juan P. Sesmero, Nickolas F. Frentes and Richard K. Perrin "Efficiency in Midwest US corn ethanol plants: A plant survey" Energy Policy 37, 2009, 1312.

[72] Juan P. Sesmero, Nickolas F. Frentes and Richard K. Perrin "Efficiency in Midwest US corn ethanol plants: A plant survey" Energy Policy 37, 2009, 1312.

alienated by federal mandates/subsidies for corn-based biofuel. U.S. livelihoods that are hindered by federal mandates like the Renewable Fuel Standard largely include fishing communities in the Atlantic Ocean as well as businesses that benefit from beach tourism along near the Gulf of Mexico and the South Eastern United States.

3.2: The Less Fortunate

We revisit the article *Algal bloom and its economic impact* referenced in the second chapter of this thesis, by Diana Conduto, Srdan Dobricic, Teresa Lettieri, Luca Pozzoli, and Isabella Sanseverino to discuss some of the negative impacts of biofuel production in the United States. Findings outlined in a table by the article illustrate an estimate of nearly one-billion U.S. dollars in annual negative economic impacts to correlate with harmful agal blooms.[73] Further, the findings in the article *Algal bloom and its economic impact* show a tremendously larger economic impact by algal blooms when it was published in 2016 from an estimate taken between 1987 and 1992. A technical report published in the year 2000 titled *Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States* provide an approximated annual average of U.S. economic toll from algal blooms to be over 49 million dollars.[74] Regarding inflation, 49 million dollars in the year 1990 is approximately equivalent to 90 million dollars in 2016. Comparing 90 million dollars to 900 million dollars illustrates an increase in economic impacts by nine times over twenty-four years. To add, the approximate sum of one billion dollars in negative impacts caused by harmful algal

[73] Diana Conduto, Isabella Sanseverino, Luca Pozzoli, Srdan Dobricic and Teresa Lettieri., "Algal Bloom and Its Economic Impact," European Commission, Joint Reseach Center, 2016, 25.
[74] Alan W. White, Donald W. Anderson, Porter Hoagland, and Yoshi Kaoru, “Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States," Woods Hole Oceanographic Institution, 2000, 4.

blooms is likely a conservative amount. The one-billion dollars mentioned does not include the freshwater and recreational damages caused by harmful algal blooms. When including freshwater and economic losses on the tourist business, the document *Algal Bloom and Its Economic Impact*, provides data to illustrate an addition of over one-billion U.S. dollars to the one billion included earlier in this paragraph. The comparison between the evidence provided in Estimated *Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States* and *Algal Bloom and Its Economic Impact* illustrate a considerable annual increase in economic damages on health expense in addition to fising and recreational communities. One can conclude that the expanse of biofuel in the United States is in coorelation with damage from a greater frequency of algal blooms and red tides.

In addition to some of the financial turmoil caused by dead zones, it is best to also revisit research by Emily Cassidy. The Environmental Protection Agency implemented the Safe Drinking Water Act in the year, 1974 to ensure that the public could consume fresh water in the United States without facing threats to human health. However, in order to match the building levels of nitrates in the groundwater due to fertilizing crops like corn, Des Moines Water Works has been using its filtration to remove nitrates at increasing rates. In 2015, the facility filtered nitrates from the groundwater one-hundred seventy-seven days that year.[75] Furthermore, the expense of nitrate filtration was evident in the source as well. For example, over the span of the mentioned one hundred seventy-

[75] Emily Cassidy, "More Ethanol Means More Toxic Water Pollution" Environmental Working Group. https://www.ewg.org/news-insights/news/more-ethanol-means-more-toxic-water-pollution (Accessed February 05, 2020).

seven days, nitrate removal costed 1.5 million dollars.[76] One can infer that expense of nitrate filtration is evident in other places as well. Furthermore, such a phenomenon is likely to add expense to utilities like water, which generally causes the most economic havoc for those of low socioeconomic status. According to the article *Environmental justice and drinking water quality: are there socioeconmic disparities in nitrate levels in U.S. drinking water?* fresh water contamination is disproportunatly prevelant in low-income, minority and agricultural communities.[77] The mentioned communities are logically the most impacted because lower socioeconomic groups are less likely to prioritize things like clean water for reasons that include working uncommon and/or more hours than common. Furthermore, those of lower socioeconomic status have less financial means to catalyze change. In synchrony, agricultural communities are also likely to experience a higher concetration of nitrate in the water table due to a closer proximety with soils that are covered with fertilizers that include nitrate.

3.3: The Political Component

United States House Representative, Richard Gephardt once said, “Ethanol is good for our environment, our nations energy security, and for the American farmers.”[78] The quote provides a tone for discourse in this subsection. Nicolas D. Loris, a research assistant at the Thomas A. Roe Institute for Economic Policy Studies contributes to discourse in this chapter by explaining how politicians in the United States have

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[76] Emily Cassidy, “More Ethanol Means More Toxic Water Pollution” Environmental Working Group. https://www.ewg.org/news-insights/news/more-ethanol-means-more-toxic-water-pollution (Accessed February 05, 2020).

[77] Christopher Campbell, Laurel A. Schaider, Lucien Swetschinski, and Ruthann A. Rudel., “Environmental justice and drinking water quality: are there socioeconomic disparities in nitrate levels in U.S. drinking water?” Environmental Health, Vol 18, No 3, 2019, 2.

[78] Gary D. Libecap, “*Agricultural Programs with Dubious Environmental Benefits: The Political Economy of Ethanol”* Rowman & Littlefield, 2003, 89.

supported ethanol recently. While many may think of President George Bush. Jr's administration as one of the first in the U.S. to aggressively embrace ethanol through federal subsidizing, both the administrations of Obama and Trump bolstered the "renewable fuel source" through policy as well. For example, according to Loris in his article *The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard* President Donald Trump wrote to his twitter followers that a "giant package" will be "great for all."[79] The "giant package" is a reference to a plan that looked to blend over fifteen-billion gallons of conventional ethanol" into the U.S. fuel supply by 2020.[80] Loris notes that this proposal further supports larger refineries at the cost of smaller ones. The analysis that fewer refineries will reap a bigger benefit from corn ethanol agrees with the information referenced by Glozer. Specifically, Glozer's findings that ten mid-western states in the U.S. reap over eighty percent of the federal benefits for corn and soybean crops illustrate that only fraction of the U.S. economy benefits from a stimulus. Noting that few benefit from corn ethanol is important because it plays into an argument that the large scale existence of ethanol in the United States may not contribute positively for citizens on the same degree.

The Renewable Fuel Standard is a product of the Energy Policy Act of 2005 and the George W. Bush administration to lower U.S. dependence on foreign oil. In the article, *The Renewable Fuel Standard and Its Challenges* by Brian Garst, President George W. Bush in fact articulated the critical importance of new fuel policy to be "a

[79] Nicolas D. Loris., "The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard," The Heritage Foundation, No 3441, 2019, 1.
[80] Nicolas D. Loris., "The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard," The Heritage Foundation, No 3441, 2019, 1.

matter of national and economic security."[81] The Energy Policy Act of 2005 "mandated that fuel suppliers blend increasing amounts of renewable fuel" in U.S. transportation.[82] Furthermore, the Energy Independence Act of 2007 bolstered the Renewable Fuel Standard by devising a plan to raise U.S. biofuel use to the hefty goal of 36-billion gallons in the year 2022. Loris expounds that the Renewable Fuel Standard "contains several sub-mandates" that respectively interact with different derivatives of biofuels. However, important to the construct of this paper, the mandate for "conventional ethanol," which pertains mostly to corn ethanol is among one of the largest developments in the Renewable Fuel Standard. Thus, one can infer that the topic of the Renewable Fuel Standard is largely synonymous with the existence of corn ethanol.

Some analysis shows that subsidies and other policy relative to the larger construct of corn ethanol in the U.S. are not effective at bringing about a greener and more environmentally safe way of life. Loris noted that the Renewable Fuel Standard "has not lived up to its environmental expectations."[83] Loris continues through his article *The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard* to provide reasons of why corn ethanol continues to be subsidized in the United States. Loris notes that "a central problem of the RFS (Renewable Fuel Standard) is not the use of biofuels themselves, but that regulators in Washington explicitly mandate them and attempt to project what current and future energy markets look like."[84] The quote in

[81] Brian Garst., "The Renewable Fuel Standard and Its Challenges," Center for Freedom and Prosperity, 2020, 1.
[82] Nicolas D. Loris., "The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard," The Heritage Foundation, No 3441, 2019, 1.
[83] Nicolas D. Loris, "The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard," The Heritage Foundation, No 3441, 2019, 7.
[84] Nicolas D. Loris, "The Administration's Ethanol Package Exacerbates the Cost of the Renewable Fuel Standard," The Heritage Foundation, No 3441, 2019, 7.

the prior sentence is interesting because it shows that motives relative to the use of biofuels in the United States are not fully predicated around the purpose of mitigating the ecological footprint, but rather for more subsidiary purposes. The quote in consideration is also important because it reminds us to think critically when analyzing the true purpose of some federal policy and mandates.

Motives relative to the two main-stream political parties in the United States (Democrat and Republican) should be considered when determining the reasons why corn ethanol is still a fuel source supported by the Renewable Fuel Standard. For example, as stated above, the Bush Jr. administration was likely motivated (at least in part) to support biofuels to mitigate reliance on the Middle East during the Iraq conflict. For Democrats, motive to support biofuel (including corn ethanol) is relevant while media sources, or supporters of the Democrat party continue to believe that using corn ethanol in the United States is best for ecosystems and mitigating the U.S. ecological footprint. In addition, one can infer that the Donald Trump administration had motive to support corn ethanol because U.S. citizens of agrarian roots are among those who supported Trump and the Republican party prior to the 2016 presidential election. In fact, a Reuters news article *Trump Decision to cut refiner biofuel wavers followed pressure from farm states: sources* by Stephanie Kelly and Jarrett Renshaw provide evidence that Trump had motive to cater to farmers. Kelly and Renshaw argue that the "U.S. Farm Belt" was a crucial "constituency" to the election of Donald Trump in 2016.[85] Additionally, some had grown "frustrated by the administration's handling of the

[85] Jarret Renshaw and Stephanie Kelly, "Trump decision to cut refiner biofuel waivers followed pressure from farm states: sources" Reuters. https://www.reuters.com/article/us-usa-election-biofuels-idUSKBN2622KA. (Accessed April 13, 2021).

Renewable Fuel Standard requiring refiners to blend billions of gallons of the corn-based fuel into gasoline."[86] The authors explain that the Trump administration had saved refiners "tens of millions of dollars in the process" of waiving biofuel requirements from being utilized for oil refineries.[87] However, due to a closer than expected race between Trump and Biden in the state of Iowa (a large contributor of corn in the United States), the Trump administration was pressured to enforce mandates on oil refiners to retain Republican support in the Farm Belt. In fact, Cheri Bustos, a Democratic Representative for Illinois said, "you get the farm vote and that can make the difference between winning a state and not winning a state."[88] Bustos's remark demonstrates how gaining support of farmers in politics is consequential to determining a victor. This paragraph analyzes some of the political motives relevant to the construct of corn ethanol in the United States.

Like trends of other recent U.S. presidents and their administrations, newly elected Joe Biden has made it clear that climate policy is a relevant subject. In fact, on his first day in office, Biden scrubbed the Keystone XL Pipeline and arranged for the U.S. to re-enter the Paris Agreement. In addition, Biden also signed multiple other executive orders with environment in mind. In the source *Optimistic Prospects for US Climate Policy in the Biden Administration*, Mark Elder notes that Biden signed an executive order seven days following his inauguration to "set an ambitious goal of net zero by

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[86] Jarret Renshaw and Stephanie Kelly, "Trump decision to cut refiner biofuel waivers followed pressure from farm states: sources" Reuters. https://www.reuters.com/article/us-usa-election-biofuels-idUSKBN2622KA. (Accessed April 13, 2021).
[87] Jarret Renshaw and Stephanie Kelly, "Trump decision to cut refiner biofuel waivers followed pressure from farm states: sources" Reuters. https://www.reuters.com/article/us-usa-election-biofuels-idUSKBN2622KA. (Accessed April 13, 2021).
[88] Jarret Renshaw and Stephanie Kelly, "Trump decision to cut refiner biofuel waivers followed pressure from farm states: sources" Reuters. https://www.reuters.com/article/us-usa-election-biofuels-idUSKBN2622KA. (Accessed April 13, 2021).

2050" regarding climate.[89] Elder's resource is valuable at helping us recognize that the Biden administration will take consideration to the environment and ecological footprint in the United States. However, Elder does not explain to what degree the Biden administration understands the Renewable Fuel Standard and its support of corn for ethanol as either a mitigator or facilitator of environmental disorder.

Contrary to some analysis provided above on the Trump Administration, a webpage by Tammy Duckworth (Democrat senator of Illinois) states the Renewable Fuel Standard was not supported by the Trump administration. Duckworth's statements are likely prompted by the Trump Administration's refusal to enforce ethanol mandates in fuel refinement. However, Duckworth neglects to note that the Trump Administration supported biofuel production but did not enforce penalties. Senator Duckworth said, "farmers across Illinois and throughout the Midwest are hurting and ethanol plants remain idled as a result of the Trump Administration's sustained abuses of the bipartisan RFS small refinery exemption program."[90] Tammy Duckworth's contributions to this paragraph is salient to analysis for a couple of reasons. First: despite Duckworth's quote pertaining to way in which the Trump Administration handled the Renewable Fuel Standard, the U.S. senator said that support for the RFS is "bipartisan." The bipartisan support for ethanol plays into a theme in this chapter, that major players in both U.S. mainstream political parties generally foster support for the construct of ethanol. Secondly: one should consider that Senator Duckworth must cater to the wants and needs

[89] Mark Elder, "Optimistic Prospects for US Climate Policy in the Biden Administration" Institute for Global Environmental Strategies, 2021, 1.
[90] Tammy Duckworth, "Duckworth Applauds Biden Administration's Renewable Fuel Standard Decision Supporting Farmers and Rural Communities" Tammy Duckworth U.S. Senator For Illinois. https://www.duckworth.senate.gov/news/press-releases/duckworth-applauds-biden-administrations-renewable-fuel-standard-decision-supporting-farmers-and-rural-communities (Accessed April 16, 2021).

of her voters to remain competitive as a U.S. senator. One way to appeal to voters in Illinois can be achieved by promoting the livelihood of farmers due to the scale of farming in that part of the United States. On a third note, Duckworth contributes to this chapter by illustrating that Joe Biden will ultimately be the fourth U.S. president in sequence to influence the Renewable Fuel Standard.

Some surmise that the answer to mitigating ecological footprint in the United States lies in the sources of ethanol. For example, some scholars credit cellulosic crops like switch grass, gamma grass and sugar-cane with holding the answer in the search for a tangible, renewable and planet friendly fuel source. Some scholars even argue that cellulosic sources of ethanol have poor energy returns and fail to practically achieve sustaniability. For example, C. Ford Runge, noted in *The Case Against More Ethanol: It's Simply Bad for Environment* that cellulosic ethanol "has proven a monumental disappointment, and the EPA has taken a big step back from requireing its use."[91] Nonetheless, sources analyzed in this chapter illustrate that the power of the vote outshines the negative economic implications of the Renewable Fuel Standard. If federal policy like the Renewable Fuel Standard were to expand ethanol policy to support a greater implementation than current trends, negative financial impacts may extend beyond hospitality and fisihing communities. For example, feeding and raising livestock could become more expensive if fuel companies doubled or tripled the percentage of ethanol in gasoline blends. Daries, Ranchers who raise livestock for slaughter, and egg farmers would all potentially compete against the fuel market. In turn, one can surmise

[91] C F. Runge, "The Case Against More Ethanol: It's Simply Bad for Environment" *Yale Environment 360*, (May 25, 2016) Acssesd April, 26, 2021 The Case Against More Ethanol: It's Simply Bad for Environment - Yale E360

that the everday consummer would also be negatively impacted due to the competition with the fuel market. This scenario plays into the food versus fuel argument. While some tenets of the food versus fuel argument are simplistic, tripling the percentage of ethanol use in the United States would certainly reflect higher food prices. Effects of higher food prices would likely negatively impact middle-class Americans and those of lower socio-economic status. Further financial burden to the mentioned socio-economic classes of U.S. citizens would hypothetically lead to a larger percentage of people beneath the poverty line. One can argue that using similar logic, less implemetantion of corn ethanol in the Renewable Fuel Standard might lead to lower food prices and financial mobility. The claim in the last sentence is simplistic. Furthermore, less ethanol use in the United States could rock the proverbial boat in terms economic stability among agrarian communities.

3.4: Chapter Takeaways

As stated at the beginning of the chapter, existance of corn derivied ethanol in the U.S. is largely the product of federal subsidies. Politicians are under pressure to keep the Renewable Fuel Standard in support of corn based biofuel. Corn growers in the midwest largely benefit from ethanol demand and federal subsidies. On the flip side, fishing communities and offshore recreational businees are negatively effected by the fertilizer runoff. However, data shows that subsidies by the Renewable fuel Standard add up to an amount greater than those who financially lose due to harmful algal blooms. It is important to also remember that over eighty percent of the mentioned agricultual subsidies are utilized by citizens of ten midwestern states. This is important because it demonstrates that the corn community is concentrated. Ultimatley, the benefits of the Renewable Fuel Standard is limited to a specific geographic region in the United States.

Conclusion

Most scholars who objectively analyze corn ethanol in the construct of providing energy for transportation in the United States, find the biofuel to do little in the way of mitigating the ecological footprint. Those who continue to support the Renewable Fuel Standard and its application of corn ethanol in the U.S. largely consist of members of the agricultural community and large corporations like Cargill that financially have the most to gain from the mandates. Most who consider all relevant networks impacted by corn and ethanol production in the United States find the fuel to be inefficient, and undeserving of the title renewable or sustainable. According to C. Ford Runge, "the predictable weakness in ethanol margins resulting from low oil prices has even led Archer Daniels Midland (ADM), one of ethanol's major advocates, to reconsider its stake in its ethanol investmant after years of aggressive subsidy-seeking."[92] The extent to which ethanol will remain a reality in the United States in the years following 2021 is unknown. However, when analyzing support of corn ethanol by the Renewable Fuel Standard in the recent past, likliness that the fuel souces will continue to provide energy to our automobiles is high. All presidential administrations from Bush Jr. to Biden have supported farmers through madates for corn ethanol. Until our politicians stake greater importance in principle than votes, financial and environemtnal turmoil will continue to be facilitated by the Renewable Fuel Standard. Ultimatley, C. Ford Runge sums up the

[92] C. Ford Runge, "The Case Against More Ethanol: It's Simply Bad for Environment" Yale Environment 360. https://e360.yale.edu/features/the_case_against_ethanol_bad_for_environment (Accessed April 26, 2021).

conclusion of this publication when he says “increasing our reliance on corn ethanol in the coming decades is doubling down on a poor bet.”[93]

To inspire positive change, leaders can continue to raise awarnes of both, the environmental implications of burning corn derived ethanol, and furthermore, the large allocation of tax dollars for the fuel source on a false pretense of renewability. I think most do little to investigate claims of sustaniability regarding corn based biofuel because research on the topic has failed to make it into mainstream media. Ultimatley, the Renewable Fuel Standard needs to forgo subsidizing of corn crops to better achive the purporse of the legislation.

[93] C. Ford Runge, “The Case Against More Ethanol: It's Simply Bad for Environment” Yale Environment 360. https://e360.yale.edu/features/the_case_against_ethanol_bad_for_environment (Accessed April 26, 2021).

Bibliography

Anderson, Donald M, Porter Hoagland , Yoshi Kaoru, and Alan W White. *Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States.* Technical, Woods Hole: Woods Hole Oceanographic Institution, 2000.

Campbell, Christopher, Laurel A Schaider, Lucien Swetschinski, and Ruthann A Rudel. "Environmental justice and drinking water quality: are there socioeconimic disparities in nitrate levels in U.S. drinking water?" *Environmental Health*, 2019: 1-15.

Cassidy, Emily. "More Ethanol Means More Toxic Water Pollution." *Environmental Working Group*, 2016.

Chang, Brenda, and Alissa Kendall. "Estimating life cycle greenhouse gas emissions from corn-ethanol: acritical review of current U.S. practices." *Journal of Cleaner Production*, 2009: 1175-1182.

Conduto, Diana, Srdan Dobricic, Teresa Lettieri, Luca Pozzoli, and Isabella Sanseverino. *Algal bloom and its economic impact.* Technical, Ispra: European Commission, 2016.

Donner, Simon D, and Christopher J Kucharik. "Corn-Based ethanol production compromises goal of reducing nitrogen export by the Mississippi River." *Proceedings of the National Academy of Sciences of the United States of America* 105, no. 11 (March 2008): 4513-4518.

Duckworth, Tammy. "DUCKWORTH APPLAUDS BIDEN ADMINISTRATION’S RENEWABLE FUEL STANDARD DECISION SUPPORTING FARMERS AND RURAL COMMUNITIES." *Tammy Duckworth U.S. Senator For Illinois.*

February 22, 2021. https://www.duckworth.senate.gov/news/press-releases/duckworth-applauds-biden-administrations-renewable-fuel-standard-decision-supporting-farmers-and-rural-communities (accessed April 16, 2021).

Edmunds, Dan. "E85 vs. Gasoline Comparison Test." *Edmunds.* April 29, 2009. https://www.edmunds.com/fuel-economy/e85-vs-gasoline-comparison-test.html (accessed April 30, 2021).

Elder, Mark. *Optimistic Prospects for US Climate Policy in the Biden Administration.* Breifing Note, Kamiyamaguchi: Institute for Global Environmental Strategies, 2021.

Fingerman , Kevin R, Daniel M Kammen, Michael H O'Hare, and Margaret S Torn. "Accounting for the watee impacts of ethanol production." *Environmental Research Letters*, 2010: 1-7.

Garst, Brian. "The Renewable Fuel Standard and Its Challenges." *Center for Freedom and Prosperity*, 2020: 1-3.

Glozer, Ken G. *Corn Ethanol Who Pay? Who Benefits.* Stanford: Hoover Institution Press, 2011.

Halliday, Stuart L, and Mary Leigh Wolfe. "Assessing Ground Water Pollution Potential From Nitrogen Fertilizer Using A Geographic Information System." *Water Resources Bulletin* 27, no. 2 (April 1991): 237-245.

Howarth, Robert W, Kyle R Mankin, Hans W Paerl, Andrew N Sharpley, and Thomas N Simpson. "The New Gold Rush: Fueling Ethanol Production while Protecting Water Quality." *Journal of Environmetal Quality* 37, no. 2 (2008): 318-324.

Kelly, Stephanie, and Jarrett Renshaw. "Trump decision to cut refiner biofuel waivers followed pressure from farm states: sources." *Reuters.* September1 11, 2020. https://www.reuters.com/article/us-usa-election-biofuels-idUSKBN2622KA (accessed April 13, 2021).

Loris, Nicolas D. "The Administration's Ethanol Package Exacerbates the Cost of the Renewable fuel Standard." *Backgrounder*, 2019: 1-10.

Maceno, Marcell M.C., Karina Scurupa Machado, Robson Seleme, and Zattar C Izabel. "Carbon footprint in the ethanol feedstocks cultivation - Agricultural CO2 emission assessment." *Agricultural Systems 157*, 2017: 140-145.

Runge, C Ford. "The Case Against More Ethanol: It's Simply Bad for Environment." *Yale Environment 360.* May 2016. https://e360.yale.edu/features/the_case_against_ethanol_bad_for_environment (accessed April 26, 2021).

Tidwell, Vince, Amy Cha-tein Sun, and Len Malczynski. "Biofuel Impacts on Water." *Sandia Report* (Sandia National Laboratories), 2011: 3, 13, 17.

Upton, Harold F. "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fising Industry." *Congressional Research Service*, 2011: 1-14.

Ward, Mary H. "Too Much of a Good Thing? Nitrate form Nitrogen Fertilizers and Cancer:." *Reviews on envirionmental health* 24, no. 4 (2009): 357-363.