Bioenergy Facilities In the Carolinas and Their Potential Environmental Justice Impacts

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Alysa Delgado, James Ellsmoor, Andria Fernandez, Jocelyn Keung, Caroline Lindquist, Megan Neligan, Tanay Tailor
Dr. Andrew George, Capstone Spring 2016 – ENEC 698
University of North Carolina at Chapel Hill

Introduction

Renewable energy mandates and targets have spurred the growth and utilization of biomass in recent years (Alakoski, *et al.*, 2016; Buchholz *et al.*, 2015; Handler *et al.*, 2014; Helin *et al.*, 2013; Malico *et al.*, 2016). Biomass is a general term that includes a variety of organic matter, such as landfill or animal waste, that is burned as fuel. Wood biomass in particular has seen significant increases in production (Malico *et al.*, 2016; Repo *et al.*, 2015) due to the widespread belief that it is a carbon neutral energy input (Buchholz *et al.*, 2015; Helin *et al.*, 2013; Nepal *et al.*, 2015). The Southeastern United States is a major exporter of woody biomass; Drax, which operates the largest power station in the United Kingdom (UK), stated that 58% of its wood biomass originated from the United States in 2014 (Buccholz *et al.*, 2015).

A typical life cycle of woody biomass sourced in the Southeastern United States is as follows:

(1) trees are planted and cut down;
(2) wood is transported to wood pellet facilities via trucks;
(3) wood is manufactured into pellets;
(4) pellets are transported to ports via trains;
(5) pellets are shipped to the UK;
(6) pellets are transported from the port to power plants via trains;
(7) pellets are burned as fuel (Dwivedi *et al.*, 2014).

Life cycle assessments (LCA) of woody biomass are complex and existing analyses have conflicting conclusions regarding the carbon neutrality of this woody biomass (Haberl *et al.*, 2012; Helin *et al.*, 2013; Klein *et al.*, 2015; Sedjo, 2013). Discrepancies in literature are attributed to a lack of standardization of LCA methodology; there exists an incredible number of potential combinations of variables and assumptions to be included in each LCA that vary with each study and result in differing conclusions (Haberl *et al.*, 2012; Helin *et al.*, 2013; Klein *et al.*, 2015; Sedjo, 2013).

The Southeastern United States is also a major agricultural region and has many farms that function as concentrated animal feeding operations (CAFOs). Hog farms produce large quantities of biogas, which is combusted in biomass plants.

In addition to the contested carbon neutrality of biomass production and combustion, these processes have many climatic, health, and environmental impacts that are overlooked in LCA's that focus only on biogenic carbon emissions. Some of these effects include changes in surface albedo (Helin *et al.*, 2013; Klein *et al.*, 2015), tradeoffs with ecosystem services (Malico *et al.*, 2016; Repo *et al.*, 2015), health concerns related to reduced air quality from combustion (Gilman *et al.*, 2015), trade-offs with food security (Johnston *et al.*, 2015), and harmful emissions during storage of woody biomass (Alakoski *et al.*, 2015). In addition, inputs such as fertilizers, harvesting machineries, pesticides, and other site preparation activities contribute significantly to the environmental effects of biomass products, but few studies currently incorporate these factors (Klein *et al.*, 2015). Of 26 European and North American peer-reviewed studies since 2000, fewer than 20% of studies incorporated housing and accommodation, piling and burning, clearing, pesticides, herbicides, planning of forest operations, and/or pruning in their assessments of biomass production (Klein *et al.*, 2015).

Due to the lack of accounting and standardization in analyses of biomass production and combustion, we were interested in testing for issues related to environmental justice in the Southeastern United States. Specifically, we examined biomass facilities in North and South Carolina. North Carolina policy mandates two bioenergy minimums for poultry and swine waste in its Renewable Portfolio Standard (Ebers *et al.*, 2015). Thus, it is imperative to develop a comprehensive understanding of all the impacts of this technology on the environment and its inhabitants to evaluate the utilization of biomass for energy production (Puneet *et al.*, 2009).

Literature Review

Minimal research has been performed linking environmental justice issues and the emerging bioenergy industry. The Partnership for Public Integrity conducted research on the topic but only for the state of Pennsylvania (Booth, 2012). The study explored environmental justice tracts based on census tracts with at least 20 percent poverty rate and 30 percent minority population. Analysts then assessed air pollution from specific plants located in these environmental justice areas. The study further found that because of the form and scale of energy production at the facilities, bioenergy facilities are considered a synthetic minor emissions source; therefore they avoid Best Available Control Technology permitting, leading to relatively high rates of pollution. Energy funding from the state of Pennsylvania is further encouraging the location of bioenergy facilities in these Environmental justice areas with grants ranging from $1 million to $39 million.

The focus on air pollutants in the study led us to further research the harmful effects associated with the industry.

We found that combustion of biomass releases many harmful air pollutants that include Sulfur Dioxide, Nitrogen Dioxide, Carbon Monoxide, and particulate matter (Boman *et al.*, 2003; Ezzati *et al.*, 2001). These pollutants can cause an increase in acute respiratory infections, acute asthma (Boman *et al.*, 2003; Ezzati *et al.*, 2001), chronic respiratory irritation, lung cancer, chronic bronchitis (especially in young children), aggravation of pre-existing lung disease, and a reduced life expectancy (Kampa *et al.*, 2008). In addition, an increase in the use of biomass fuel has been associated with higher levels of indoor air pollution and an increase in respiratory diseases such as infections, pneumonia, tuberculosis, and chronic obstructive pulmonary disease (Fullerton, 2008).

Air pollution has wider consequences beyond respiratory conditions. Air pollution may be linked to cardiovascular damage; a 10 microgram per cubic meter increase in fine particulate matter has been associated with an 8%-18% increase in mortality due to cardiovascular disease (Pope III *et al.*, 2004). Even short-term exposure to particulate matter increases the risk of hospitalization due to cardiovascular damage (Dominici *et al.*, 2006).

Air pollution has also been linked to causing harm to future generations as well. A study of pregnant women in North Carolina has indicated that particulate matter 2.5 is associated with a 6.8% increase in the risk of pre-term birth (Chang *et al.*, 2011). Children who are born prematurely are associated with health risk factors such as increased blood pressure and insulin resistance at age thirty (Parag *et al.*, 2007). Although there are clear impacts of air pollution on human health, it is difficult to quantify how much air pollution from the burning of biomass contributes the overall poor air quality (Naeher *et al.*, 2007).

Noting the extensive harmful effects from air pollutants from burning woody biomass, we then explored the health effects from biogas and its facilities, which are gaining prevalence in the Carolinas due to the extensive hog industry (Maosheng & Gehua, 2003; Tian, 2012). Biogas has become an important topic for research as renewable energy increases in global importance. It is widely lauded for reducing greenhouse gas (GHG) emissions and generating energy from what would otherwise be a waste product (LingYu, YanLi, & PeiDong, 2009; Maosheng & Gehua, 2003; Tian, 2012).

The American Biogas Council (2015) estimates there is potential for 529 biogas plants from hog farms and 175 from dairy farms, based on the estimated amount of organic material available. These farms are almost exclusively concentrated animal feeding operations (CAFOs), and have been researched extensively. Furuseth (1997) charts the restructuring of hog farming in North

Carolina from a family-run agricultural business to an agro-industrial sector. It highlights the explosion in hog numbers in the 1980s and 1990s and a geographic concentration of the industry in the south central area of the Coastal Plain region.

The negative health implications associated with CAFOs are of particular concern to researchers. Wing, Freedman, & Band (2002) analyze the risk of contamination into the surrounding environment from the fecal matter associated with these farms, particularly in the event of flooding or hurricanes. Wing & Wolf (2000) suggest that living close to CAFOs can seriously impact health and quality of life with symptoms ranging from mild coughs and runny noses to severe diarrhea and headaches when fecal matter leaches into groundwater. Several studies have revealed elevated levels of ammonia-nitrogen and hydrogen sulfide in close proximity to hog farms, which are generally attributed to be causes of illnesses in residents (Blunden & Aneja, 2008; Wilson & Serre, 2007; Blunden, Aneja & Westman, 2008). For biogas facilities, these environmental contaminants from CAFOs combine with the air pollutants associated with the energy production, making health consequences even more severe.

It has also been suggested by Wing, Cole & Grant (2000) that CAFOs disproportionately affect the poor and communities of color based on a study of hog farms in eastern North Carolina. Wing, Freedman, & Band (2002) also highlighted that flooding and associated pollution from CAFOs primarily occurred in areas inhabited by African-Americans. A similar study in Mississippi also concluded that the most detrimental impacts of the industry were most concentrated on the homes of people of color (Wilson *et al.*, 2002).

A number of the bioenergy facilities that we mapped in our research were biogas facilities sourced by hog waste. Noting the research showing that CAFOs are disproportionately located in communities of people with color, we wondered if the same pattern held true for bioenergy facilities as it does in Pennsylvania.

Given North Carolina's history with environmental justice issues, beginning with the Warren County PCB Case in 1982, we hypothesized it was likely that poor communities of color are being targeted by the bioenergy industry (Federal Government). In 1994 President Clinton issued Executive Order 12898 *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.* The order sought to "focus attention on the health and environmental conditions in minority, tribal, and low-income communities with the goal of achieving environmental justice" (Federal Government).

This order has not sufficiently prevented environmental racism. A major coal ash spill in 2015, which was exacerbated by the improper disposal of waste by plants located in poor, black communities, and the Roger-Eubanks landfill case in Chapel Hill, North Carolina that has

continued over the past forty years, show that environmental racism is clearly still an issue in the state (Newkirk, 2016)("Summary" EPA). In Robert Bullard's Book *Dumping in Dixie*, he claims that local governments and big businesses take advantage of people who are politically and economically powerless by locating facilities in places where there is lax enforcement of environmental regulations. He also examines five case studies in Louisiana, Alabama, Texas, and West Virginia where hazardous waste facilities and landfills have been unjustly located in low-income communities of color (Bullard, 2000). Many of the bioenergy facilities that we mapped in our analysis are located atop old landfills. This further points to our hypothesis that environmental justice areas may be disproportionately affected by the bioenergy industry.

Revisiting the Pennsylvania study on environmental justice and biomass energy from a financial perspective, we found even greater incentive to create a similar source for the Carolinas due to its high incentives for biomass production. A 2012 study by Zhimei Guo and her team with the more recent study by Anna Ebers and her team put a weighted average of policies for each state to come up with an ultimate ranking – and for two variations out of three calculations, North Carolina came in first place (Guo *et al.* 2012). Interestingly, the 2016 study notes that North Carolina neither has the *greatest* number of incentives in total, nor any woody biomass specific policy in place; the closest the state comes is its RPS, which has two bioenergy minimums for poultry and swine waste (Ebers *et al.* 2015). At first, it seems discrepancy is rooted in the weight the 2012 study puts on tax incentives, grants, and general financing; however, North Carolina was actually 2nd when these were weighted most heavily, and first when rules and regulations, as well as education and consultation, were slightly more evenly distributed (Guo *et al.* 2012).
The study did not make a weight for biomass specific policies, so when comparing to the Ebers study, it seems the type of policy matters more than the specific technology or quantity (Guo *et al.* 2012, Ebers *et al.* 2016).

Having these strong incentives for biomass further necessitates the understanding of the environmental effects that the industry has on the surrounding land and its residents. Analysing the pattern of location for the facilities is the first step in ensuring that no population shares a disproportionate burden of negative externalities from the new industry. Our research aims to fill that gap and ensure the environmental justice goals of Executive Order 12898 are actually met.

Research Question

Academics such as Steve Wing have discussed the implications of hog farming in North Carolina, but have often not included an analysis of the additional implications for environmental justice raised by bioenergy use of these facilities (e.g. Wing & Wolf, 2000; Wing, Cole & Grant, 2000; Wing, Freedman, & Band, 2002). Other forms of energy generation, such as coal power

plants, have also been examined for their environmental justice implications in much greater detail.

The literature on environmental justice issues caused by agricultural, industrial and energy-generating facilities is comprehensive. However, there remains a gap on the environmental justice issues surrounding bioenergy. An exception is Booth (2012), which directly links biomass facilities with environmental justice areas in Pennsylvania. This study finds many biomass facilities in close proximity to environmental justice areas, while acknowledging the need for further research. As Pennsylvania has a different socioeconomic and racial makeup to the Carolinas, it is therefore necessary to carry out a study in more depth to link environmental justice and biomass in this very different geography.

This study aims to fill the gap in the literature by asking: are bioenergy facilities in North Carolina and South Carolina disproportionately located in communities with high proportions of both low income families and people of color? In this analysis, we sought to determine if the Carolina's bioenergy production contributes to environmental justice issues. Specifically, we considered if an environmental justice screen demonstrates a pattern where communities of color are disproportionately affected by the adverse impacts of bioenergy facilities.

Methods

To discover what bioenergy facilities producing energy were present in North and South Carolina, we used the North Carolina Utilities Commission (NCUC) docket search. On the NCUC website, there is a compiled list of registered open and closed facilities. We limited our project search to those registered with the NCUC to gather a non-biased population size, as all of these projects obtained their operational status through the same process. For this project, we were only interested in bioenergy, so we filtered for those sites before gathering more site specific information; this included their exact energy source, owner, addresses, GPS coordinates, capacity, and limited water and air pollution data.

In order to determine whether or not bioenergy facilities are contributing to potential environmental injustice within the Carolinas, we had to define what constitutes an environmental justice area. We mimicked a study completed by the Massachusetts State Government, as their project seemed rather progressive in the Environmental Justice field. They calculated Environmental Justice areas based on 3 fields: >25% non-white, average median income < the state average, and >25% English language isolation. Due to limitations of acquiring the English language isolation data, our EJ Areas are calculated using the first two fields.

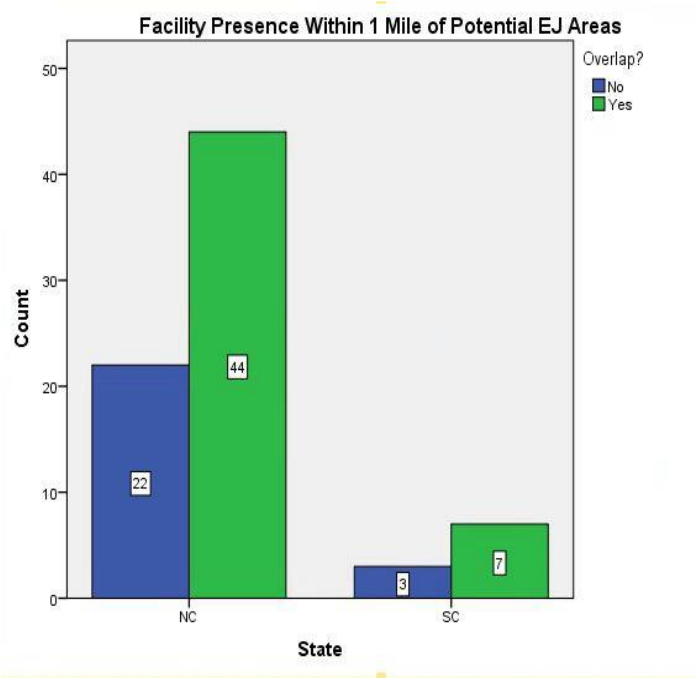
To determine these areas, we downloaded demographic data from the American Community Survey at the census block group level. This data included the racial makeup by age and income breakdowns of NC and SC. Within the attribute table of the combined dataset, we added fields based on percent minority and relative median income ratio. A new field was created denoting whether or not the census block group was a potential Environmental Justice area. This binary field was calculated using the Field Calculator function in ArcMap. GEOIDs of the block groups were queried for having both a minority percentage greater than 25 and greater than 50% of the population making less than the respective state averaged median income. This indicator field was then selected for, highlighting only these block groups, and exported to show locations within both states considered a Potential EJ Area.

Using the list of facilities gathered from the NCUC docket search, we imported their locations as X,Y coordinate points. This point layer was then overlaid across our potential EJ Areas layer. Using the Select by Location tool in ArcMap, facilities that were directly in, within a 1-mile radius, or within a 2-mile radius from our previously determined Potential EJ Areas were highlighted. For the block groups highlighted, respective binary fields were added to the dataset attribute table. We chose these three distances as buffers for feasibility of data calculations, but also because we know that adverse water and air quality effects can travel at least 2 miles away. We assumed that residents within 2 miles of the facility will face the greatest hardship from the energy production's adverse effects due to the close proximity.

Results

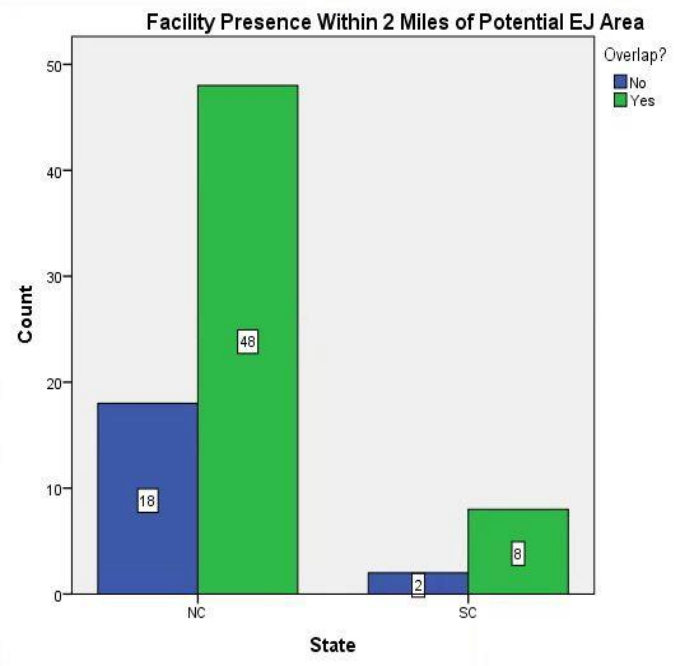
A map was created showing the overlay of facilities and potential EJ areas for North and South Carolina (Appendix 1, Figure 1). Visually, there exists a clear pattern showing a positive association between presence of a bioenergy project and proximity to a potential EJ area. Considering the aggregate projects in North Carolina and South Carolina (79), we found that 50 percent of them were located directly and entirely in a potential EJ area. When we looked at what projects were within 1 mile of a potential EJ area (Figure 2), we found that there were twice as many projects located within 1 mile of a potential EJ area in North Carolina than projects beyond 1 mile of a potential EJ area. In the same analysis we found that South Carolina had more than double the number of identified bioenergy projects within 1 mile of a potential EJ area. This suggests that 67 percent of the time a bioenergy project will be located within 1 mile of a potential EJ area.

Figure 2.



When we looked at projects within 2 miles of a potential EJ area (Figure 3), we found that almost three times as many projects were located within 2 miles of a potential EJ area--72 percent of the total projects for North Carolina. In South Carolina, there were four times as many projects within 2 miles of a potential EJ area--80 percent of the total projects for South Carolina.

Figure 3.



The primary limitations of our study involved data collection. The sample size of our study was smaller because many South Carolina projects were not included. Several South Carolina projects were not part of the NCUC's database and were excluded in order to use projects from a consistent database. A larger sample size would allow for a more accurate representation of the total number of bioenergy facilities that are located in EJ areas. Furthermore, we excluded outliers, which decreased the total amount of facilities in our study. For example, the Bucksteam Combined Coal station was excluded because the size of the project was almost double the size of the projects in the EJ areas.

Data collection limitations also extended to the case study analyses of both water and air. Using the Environmental Protection Agency's Enforcement and Compliance History Online (ECHO) database search, we were able to collect data on both the amount of toxic pollutants emitted and the number of Clean Air and Water Act violations obtained from bioenergy facilities. However, this data was insufficient; as few as 40 out of 83 total facilities had available data on air pollution, and only 27 out of 83 total facilities had available data on water pollution. Without a large sample size, we were unable to conduct statistically significant tests on whether or not bioenergy facilities located within 2 miles or less of an EJ area emitted both higher levels of air and water toxicants. Instead, we examined two case studies on water and air quality impacts attributed to specific bioenergy facilities.

Water Case Study

The 1972 Clean Water Act proposed that all chemical discharges into the nation's waters are unlawful unless specifically authorized by a permit obtained from the Environmental Protection Agency. Once a facility obtains a NPDES permit they are authorized to discharge but at a regulated amount. The NPDES permit requires industries to attain the best practicable control technology applicable to each pollutant discharged, and for municipalities at least secondary treatment of their discharges. The permit is granted with the condition that facilities will maintain records of their activities and carry out effluent monitoring.

The Enforcement and Compliance History Online provides a searchable database that includes facility-specific data regarding Clean Water Act compliance and discharge.

A suboptimal number of facilities had available data so we decided to highlight a project through the form of a case study and explore compliance and discharge numbers for a specific bioenergy project. We considered one specific project, the Weyerhaeuser NR Company located in Vanceboro, North Carolina, to get an understanding of water quality impacts due to bioenergy plants. The Weyerhaeuser NR Company is located directly in an EJ area (Figure 1).

In the last 11 of 12 quarters, Weyerhaeuser has been in non-compliance with the Clean Water Act. They have consistently exceeded their permitted discharge volumes of Methanol, chlorine dioxide, hydrochloric acid, hydrogen sulfide, ammonia, acetaldehyde, chlorine, formaldehyde, manganese compounds, and phenol. In the last decade, average production of all chemicals has increased by more 5 million lbs. Until 2010, the company managed the waste by either treating it or releasing it; Weyerhaeuser now utilizes a new method of managing the waste called "energy recovery". Overall production of chemical waste has increased, but the proportion being released has decreased. Discharge quantities still reach about one million lbs per year. One hundred percent of ammonia and manganese compounds produced are discharged, as well as seventy five percent of phenol, sixty percent formaldehyde, and roughly thirty percent of hydrochloric acid and acetaldehyde. All of the chemicals are released at a non-zero percentage.

The Clean Water Act came into place to prevent harmful backlash of pollution. When there is a violation, waters become hazardous. North Carolina has many water treatment programs in place, but contamination is still possible and exposure to wildlife is not considered. Reports suggest that swallowing even small amounts of ammonia can cause irritation to the mouth and throat (United States Department of Health and Human Services, 2004), but does not have as severe health consequences as manganese compounds. Several case reports of oral exposure to high doses of manganese have described neurological impairment as an effect, but details of exposure necessary to establish direct causation are lacking and further research is needed (World Health Organization, 2011). Phenol can be quite toxic to humans via oral exposure. Animal studies involving oral exposure to phenol have resulted in reduced fetal body weights, stunted growth, and abnormal development in the offspring of animals exposed to phenol by the oral route (United States Environmental Protection Agency, 2016).

While complete data is needed to make comparative analysis, through looking at this case study we know that non-compliance does occur and can result in adverse effects. This leaves room for future research to both gather more project specific data and analyse discharge quantities in order to identify environmental injustices.

Air Case Study

Environmental justice issues are often linked with poor community health outcomes due to various factors related to that particular environmental justice issue. One such factor, relevant to bioenergy facilities in the Carolinas, is air pollution. According to Robert Bullard, who is widely considered the father of environmental justice, "virtually all of the studies of exposure to outdoor air pollution have found significant differences in exposure by income and race" (Lawson, Westra 1995). Thus, we sought to explore whether or not significant differences in exposure to

air pollution by income and race existed for bioenergy facilities in North Carolina and South Carolina.

Due to time constraints and a lack of available data online, we were unable to collect air pollution data on all of the facilities compiled in our docket. However, we still wanted to explore whether or not these bioenergy facilities contributed to environmental injustices. To highlight this issue, we selected the Florence Mill Power Plant for analysis because it represented the worst, reported facility in terms of air pollution. Although selecting the Florence Mill Power Plant limits the generalizability of our study, as it represents one end of the extreme, the point of this case study is to examine environmental justice issues associated with bioenergy facilities. Due to a lack of data, many facilities may or may not be similarly as detrimental in terms of air pollution as the Florence Mill Power Plant. However, within the limitations of our study, the Florence Mill Power Plant was a prime example of providing evidence for potential environmental justice issues associated with bioenergy facilities. Further research needs to be conducted to make this same type of analysis for all bioenergy facilities in North and South Carolina.

Over the last eleven quarters, which spans a time period of October 2013 to June 2016, the Florence Mill Power Plant has been issued eleven Clean Air Act violations. Each violation has been a high priority violation. Sulfur oxides are the major pollutants emitted from the plant. Exposure to these chemicals can result in adverse respiratory health outcomes such as asthma, emphysema and bronchitis. Thus, because the Florence Mill Power Plant is a repeat offender, the residents living in areas around the plant have not only been exposed to these toxic materials but have had a chronic exposure to sulfur oxides. Chronic exposure to any toxic material will lead to poorer health and further research should be conducted into the overall health of the community surrounding the Florence Mill Power Plant.

Furthermore, according to our data, the Florence Mill Power Plant is directly located in an EJ area (within less than a one-mile radius). Thus, the residents in the community surrounding the plant are more likely to be poor and persons of color. Not only does this finding suggest environmental injustice, according to Robert Bullard's definition, it also begs the question, why has this issue not been addressed? Although the Florence Mill Power Plant has had multiple violations in the past three years, it has only been fined a total amount of $36,000. The lack of institutional control and prolonged nature of this issue is surprising; according to the EPA's protocols for high priority violations, "if an HPV has not been addressed within 24 months of Day Zero, the Region shall notify the director, and provide an assessment of whether or not federal action is warranted" (U.S. EPA 2014). The Florence Mill Power Plant has not been held accountable for its actions and the communities surrounding the plant have been unfairly

exposed to higher levels of pollutants. Further research and action needs to be taken to quantify the health outcomes due to exceedingly high exposure levels.

Conclusion

Our data analysis demonstrates a strong pattern of bioenergy facilities being located in or in proximity to environmental justice areas. This trend reveals an environmental justice issue of the development of these bioenergy plants, which are not carbon neutral or renewable as policy often purports them to be (Haberl *et al.*, 2012). The result of their development and operation may result in a disproportionate burden of water and air pollution in these communities. While our current research already provides ample support for the likelihood of a bioenergy plant being developed in an EJ area, our team hopes to expand our research in the future in a variety of ways to gain a better understanding of the effects of these facilities on communities that burn biomass from the Carolinas.

One area for future research is a finer-scale analysis of site-specific pollution. At this time, we could find data for a few facilities; the data we found was not sufficient for a comprehensive analysis of all our plants. In the future, we hope to conduct case studies for each bioenergy facility currently included in our research. This will allow us to better understand the measurable effect of bioenergy plants in these communities to confirm the extent to which an environmental justice issue exists with the development of these plants. Another approach to understand how these facilities affect North and South Carolinians would be to conduct community-based participatory research. This would complement our pollution and locational data very nicely, and allow us to compare the data to how people think or feel these facilities affect their lives.

Expanding the number of South Carolina facilities is another step we would like to take to advance our research. As explained in the methodologies, our team used all bioenergy facilities registered with the North Carolina Utilities Commission (NCUC) that were located in North and South Carolina. This method yielded very few plants in the South Carolina region. The South Carolina Public Services Commission (PSC) did not have a robust database like that of North Carolina. In the future, we hope to partner with the PSC in order to have a larger sample size of South Carolina projects to confirm the pattern holds with a larger survey.

Lastly, the Southeastern United States is a primary exporter of biomass (typically wood pellets) to the United Kingdom (Buccholz *et al.*, 2015). It would be interesting to take a cradle-to-grave approach in our future research to determine if biomass from the Carolinas used for bioenergy throughout the world results in environmental justice issues. At the outset of our research, we hoped to include sites in the U.K. in our dataset; we were able to get biomass plant and demographic data, but due to time constraints did not include these sites in our analysis. In the

future, working with a government commission similar to the NCUC or even with the exporters of wood pellets may grant us access to the information we require.

Ultimately, there is a clear trend of the development of these bioenergy plants in environmental justice areas throughout North and South Carolina, leading us to conclude there is a disproportionate burden of the effects of these plants on these communities. Our future research will allow us to quantify the extent of these effects both in the Carolinas and in other parts of the world that burn biomass from this region.

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Appendix A

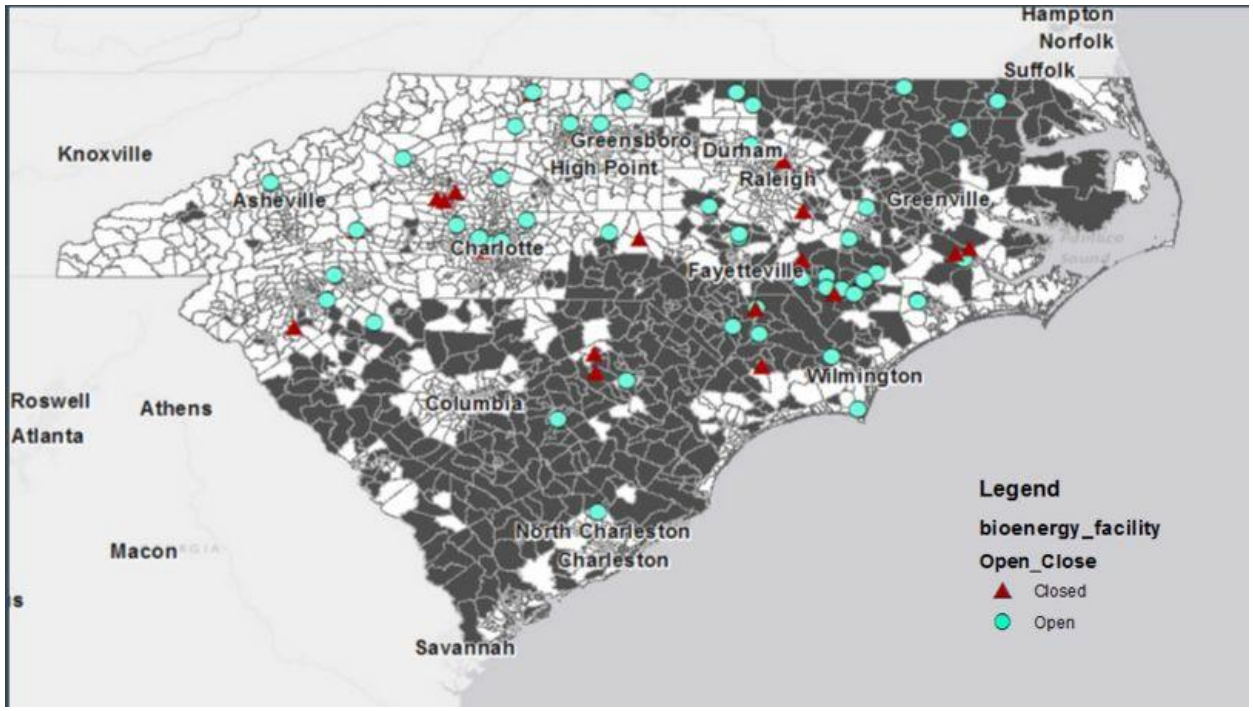

Figure 1. Dark gray areas denote highlighted potential EJ areas based on our calculated fields of percent minority and median income ratio. Red triangles are registered facilities with a closed status, while blue circles are registered facilities with an open status.

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