SOCIO-ECONOMIC IMPACTS OF MERCURY CONTAMINATION IN SOUTHERN ECOREGIONS

by

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IN SOUTHERN ECOREGIONS

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ABSTRACT

Mercury (Hg) is a naturally occurring metal that is toxic to humans and can enter the human body through the consumption of mercury-contaminated fish. A general West to East pattern of increasing mercury concentrations was found within ecoregions of the South Central United States. Also, African Americans were found to overall consume more fish than Caucasians and populations with a lower education level eat fish more often and overall consume more fish. In this study, GIS (Geographic Information Systems) and 2010 United Stated Census data were used to compare the location of at-risk populations of people to the mercury levels of fourteen Southern ecoregions. Economic status, education level, age, and ethnicity were mapped within these ecoregions. A comparison was conducted to see if there was a relationship between high mercury levels in ecoregions and large numbers of the at-risk populations. The most at risk populations were located in the Eastern part of the six-state study area and should be the focus of education efforts to help the public understand the hazards of consuming mercury-contaminated fish.

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INTRODUCTION

Mercury can get into the atmosphere one of two ways, naturally or through human activities. Mercury occurs naturally in the environment; volcanos discharge mercury into the air, and elemental mercury is released from the ocean (1). Human activities can also produce and emit mercury into the atmosphere. Activities such as the combustion of coal and the burning of waste (2) contribute the most to introducing mercury into the atmosphere. Once mercury has been released into the atmosphere, it can find its way into aquatic ecosystems. The primary way that mercury is put into the water system is from rainfall or snowfall (2). Once in the water, mercury can be methylated, have a hydrogen atom replaced by a methyl group (3), and turned into methylmercury (MeHg) (4). This MeHg is then ingested by fish and other aquatic organisms and bioaccumulates, amplifies in concentration, as it goes up the food chain.

One of the most prominent examples of MeHg poisoning to humans is Minamata Bay, Japan. After decades of consuming contaminated fish, the people of Minamata noticed that their friends and family members were acting strangely. Today, we know that these "strange" behaviors were the results of MeHg poisoning in the nervous systems of the Minamata Bay residents (5). The most common way for MeHg to enter the human body is through the consumption of fish containing MeHg (6). There are serious health effects associated with the human consumption of MeHg. Once in the human body, MeHg "acts as a neurotoxin" targeting the nervous system and the brain (7). Some effects of ingesting large quantities of MeHg include ataxia - loss of muscle coordination (8) - visual field constriction, tremors, and dysarthria - stuttering speech (9, 10). These effects, along with many others, can eventually lead to death.

Anyone who eats fish is at risk of consuming MeHg, but there are some groups of people that are more at risk than others. Young children and pregnant women are most at risk for MeHg poisoning from contaminated fish (7). The bodies of young children are still developing, so any attack on their nervous system could be detrimental. Pregnant women can pass the MeHg on to their developing embryos which are "five to ten times more sensitive than adults" (4). MeHg poisoning in developing embryos can lead to birth defects and other illnesses. Another group of people at a higher risk of MeHg poisoning are individuals who rely on fishing as their main source of sustenance.

To limit the number of MeHg poisoning cases caused by contaminated fish, the United States Environmental Protection Agency has implemented regulations on mercury levels allowed in fish found in bodies of water. Across the United States, forty states have implemented a MeHg advisory system to warn people of the potential of MeHg contamination and to cation against consumption of fish from designated bodies of water (4). Many coastal areas also have MeHg advisories for certain types of fish (4). The EPA suggests that a fish advisory is posted when MeHg levels exceed 300 ng/g. Unfortunately; many states choose to use a higher MeHg concentration to base their advisories off of, leading to a discrepancy in the way fish advisories are administered across the United States (11). Because some states choose to adopt a higher level of acceptable MeHg concentrations, many people are at risk for consuming fish that exceed the EPA's MeHg standard.

This study focused on ecoregion specific mercury levels for largemouth bass in Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas (6). Eleven of the fourteen ecoregions in this study area have mercury levels above the EPA threshold for

safe mercury levels of 300 ng/g. Many of these ecoregions also contain high percentages of populations considered most at-risk for consuming high amounts of mercury. The objective of this study was to determine where there are higher concentrations of at-risk populations and to examine the relationship between the levels of mercury contamination of fish in ecoregions of the South Central United States and the presence of these high-risk human populations.

METHODS

In this study, we focused on ecoregion-specific average mercury levels for largemouth bass (*Micropterus salmoides*) (6) and ecoregion-specific average at-risk populations, including; education levels, income levels, age levels, and ethnicity levels for the populations within the ecoregions. Drenner et al. found that there was a West to East pattern of increasing mercury contamination within the ecoregions and that eleven of the fourteen ecoregions that were examined had mercury concentrations that were above the EPA threshold. These ecoregions were the primary focus to consider possible relationships between high mercury levels and high percentages of at-risk populations (6). Burger et al. found that two high-risk populations that were more likely to consume more fish than other populations were African Americans and people with less than a high school education (12). Added to these two at-risk populations were children (age 0-12) and women of child bearing age (age 20-44), as they are the ages most at risk of adverse impacts from consuming high concentrations of mercury. Also included were people with an income level that identified them as either the working class (earn between $19,000 and $45,000 per year), the working poor (earn between $9,000 and

$18,000 per year), or the underclass (earn $9,000 of less per year) (13), as they might not have as easy access to clean fish as people with a higher income.

In this study, we used the dataset from Drenner et al. of mercury concentrations in largemouth bass within the South Central United States (6) and census tract population data on income, education level, age, and ethnicity from the 2010 U.S. Census. Ecoregions were used as the unit of analysis because ecoregions denote areas of similar land cover and allowed for patterns to be easily seen at a higher level than individual census tracts. A GIS spatial join analysis was used to assign each census tract the spatial attributes of the overlying ecoregion. The population numbers for each at-risk population were totaled at the ecoregion level. Once the demographic data was averaged up to the ecoregion level, the percentages were calculated by taking the total number of people within each at-risk group and dividing it by the total number of people in each ecoregion and multiplying by 100 to turn it into a percent. The maps were then symbolized so that the differences in the percentages could more easily be seen (see Appendix A).

After all of the maps were created, the population maps were compared to the original mercury concentration map. This was done to see if there was a relationship between high mercury concentration levels and high percentages of at-risk populations and to determine where education efforts should be made to inform the public about the risks of consuming mercury-contaminated fish.

RESULTS

Age within the Ecoregions

The percentages of children and women of child bearing age within each ecoregion ranged from 31.3 percent to 37.8 percent. This is only a 6.5 percent difference across the ecoregions. The Texas Blackland Prairies and Western Gulf Coastal Plain ecoregions had the highest percentage of children and women of child-bearing age, while the Boston Mountains, East Central Texas Plains, and Ouachita Mountains ecoregions had the lowest percentages. The Western Gulf Coastal Plain ecoregion has mercury levels above the EPA threshold of 300 ng/g and there are 2006.9 children and women of child bearing age in this ecoregion that are at risk of consuming toxic levels of mercury from contaminated fish. There does not appear to be an evident pattern in age distribution across the ecoregions.

Income within the Ecoregions

The percentages of working class, working poor, and underclass within each ecoregion ranged from 17.2 percent to 24.4 percent. This is only a 7.2 percent difference across the ecoregions. The Boston Mountains and Southeastern Plains ecoregions had the highest percentages of working class, working poor, and underclass individuals, while the Cross Timbers, Texas Blackland Prairies, and Western Gulf Coast Plain ecoregions had the lowest percentages. The Boston Mountains and Southeastern Plains ecoregions have mercury levels above the EPA threshold of 300 ng/g, and there are 1274.7 and 1126.5 people of lower income respectively within these ecoregions that are at risk of consuming toxic levels of mercury from contaminated fish. There is a general west to east pattern of

increasing percentage of lower income populations across the ecoregions which follows the general west to east pattern of increasing mercury levels within the ecoregions.

Education within the Ecoregions

The percentages of people with less than a high school education within each ecoregion ranged from 3.2 percent to 7.5 percent. This is only a 4.3 percent difference across the ecoregions. The East Central Texas Plains and Western Gulf Coast Plain ecoregions had the highest percentage of people with less than a high school education, while the Central Great Plains and Ouachita Mountain ecoregions had the lowest percentages. The Western Gulf Coastal Plain ecoregion has mercury levels above the EPA threshold of 300 ng/g and there are 398.7 people with less than a high school education in this ecoregion that are at risk of consuming toxic levels of mercury from contaminated fish. There is a general west to east and west to south pattern of increasing populations with less than a high school education across the ecoregions which follows the general west to east pattern of increasing mercury levels within the ecoregions.

Ethnicity within the Ecoregions

The percentages of African Americans within each ecoregion ranged from 1.9 percent to 40.1 percent. This represents a significant difference of 38.2 percent across the ecoregions. The Mississippi Alluvial Plain and Mississippi Valley Loess Plain ecoregions had the highest percentage of African Americans, while the Arkansas Valley, Boston Mountains, and Ozark Highlands ecoregions had the lowest percentages. The Mississippi Alluvial Plain and Mississippi Valley Loess Plain ecoregions have mercury levels above the EPA threshold of 300 ng/g and there are 1262.7 and 1813.2 African Americans

respectively in these ecoregions that are at risk of consuming toxic levels of mercury from contaminated fish. There is a general west to east pattern of increasing percentages of African Americans within the populations across the ecoregions which follows the general west to east pattern of increasing mercury levels within the ecoregions.

DISCUSSION

This study was the first to examine the relationship between high mercury concentrations and high populations of at risk groups within the ecoregions. The patterns found in the two Burger et al. high risk populations, African American populations and populations with an education less than high school, followed the same general trend that the mercury levels followed – a general west to east pattern. The majority of the ecoregions with higher percentages of the at risk populations were also ecoregions that had mercury levels above the EPA threshold for safe levels of mercury. This means that most of the at risk populations are living in areas where it is unsafe to eat the fish that are caught in that area. Some of these areas may or may not have advisories that are easily seen which can put the people living in those areas at risk of catching and consuming fish that could be detrimental to their health and the health of their families.

There was also a general west to east pattern for low income populations that followed the pattern of increasing mercury concentrations within the ecoregions. This, combined with the patterns for African American populations and low education populations, creates a widespread issue that needs to be addressed with regards to educating the public about the hazards of consuming mercury contaminated fish. While there was no apparent pattern for the percentages of children and women of child bearing

age within the ecoregions, it is still important to make sure that the proper advisories are being sent out to the populace so people are aware that the fish they may consume is hazardous to their health.

APPENDIX A: MAPS OF ECOREGIONS WITH DIFFERENT VARIABLES

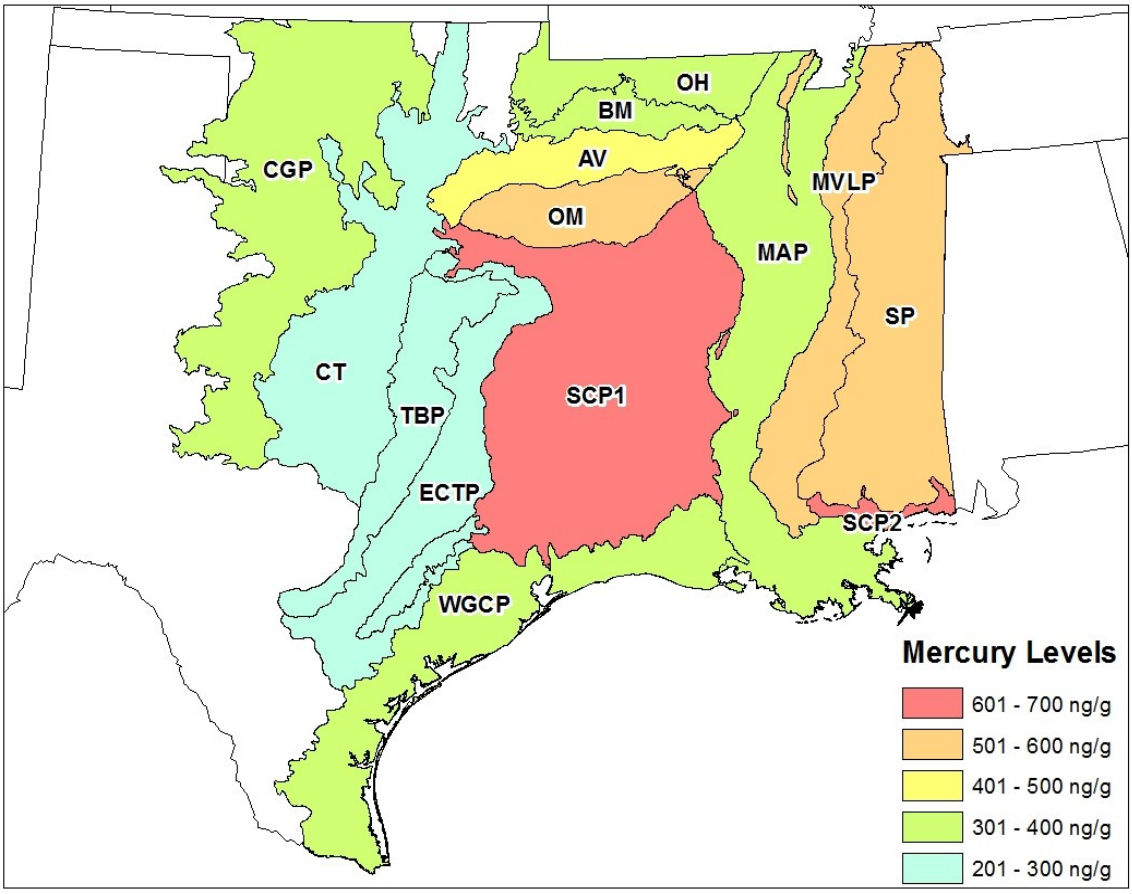

Figure 1: Mercury Levels within the Ecoregions. Blue ecoregions are ones with mercury levels below the EPA threshold of 300 ng/g and deemed safe by the EPA; green, yellow, orange, and red ecoregions are ones with mercury levels above the EPA threshold of 300 ng/g and deemed unsafe by the EPA.

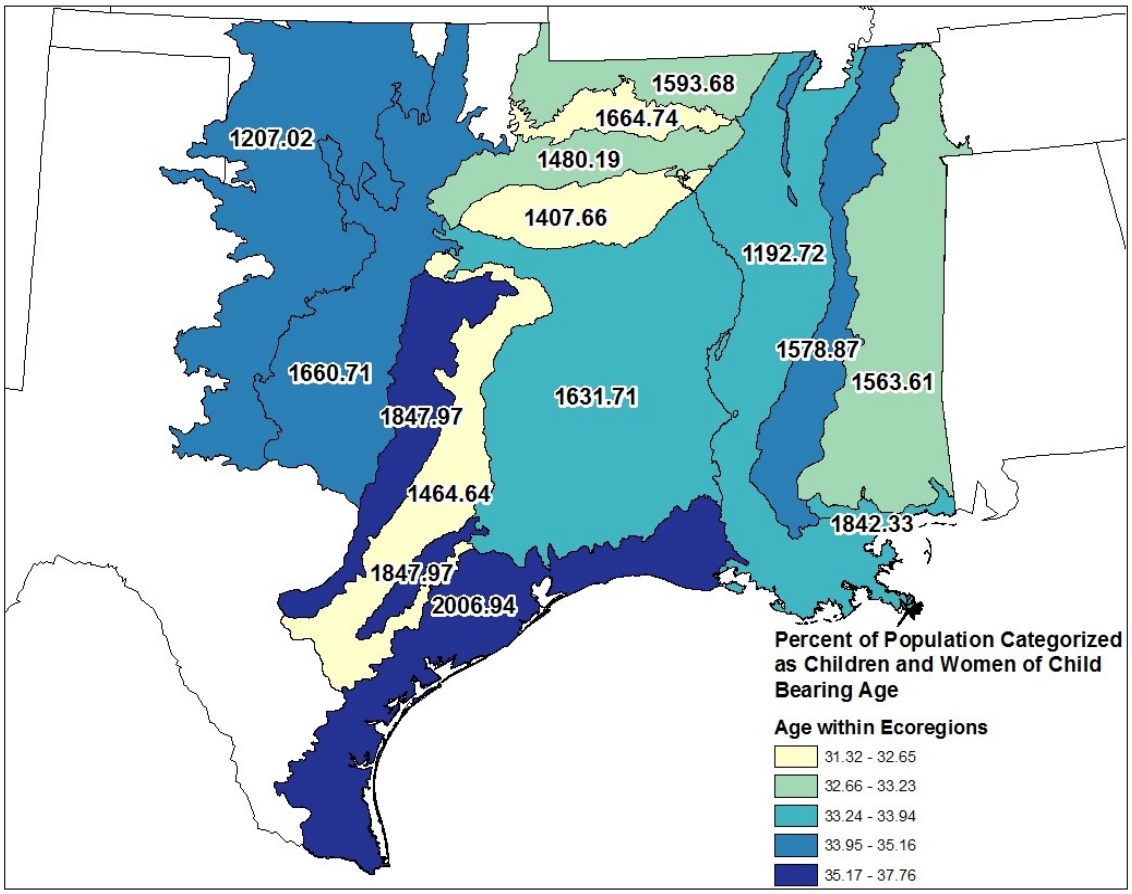

Figure 2: High Risk Age Populations within the Ecoregions. Lighter colors represent lower percentages of populations that are children and women of child bearing age and darker colors represent higher percentages. Labels show how many people in both categories are within the ecoregions.

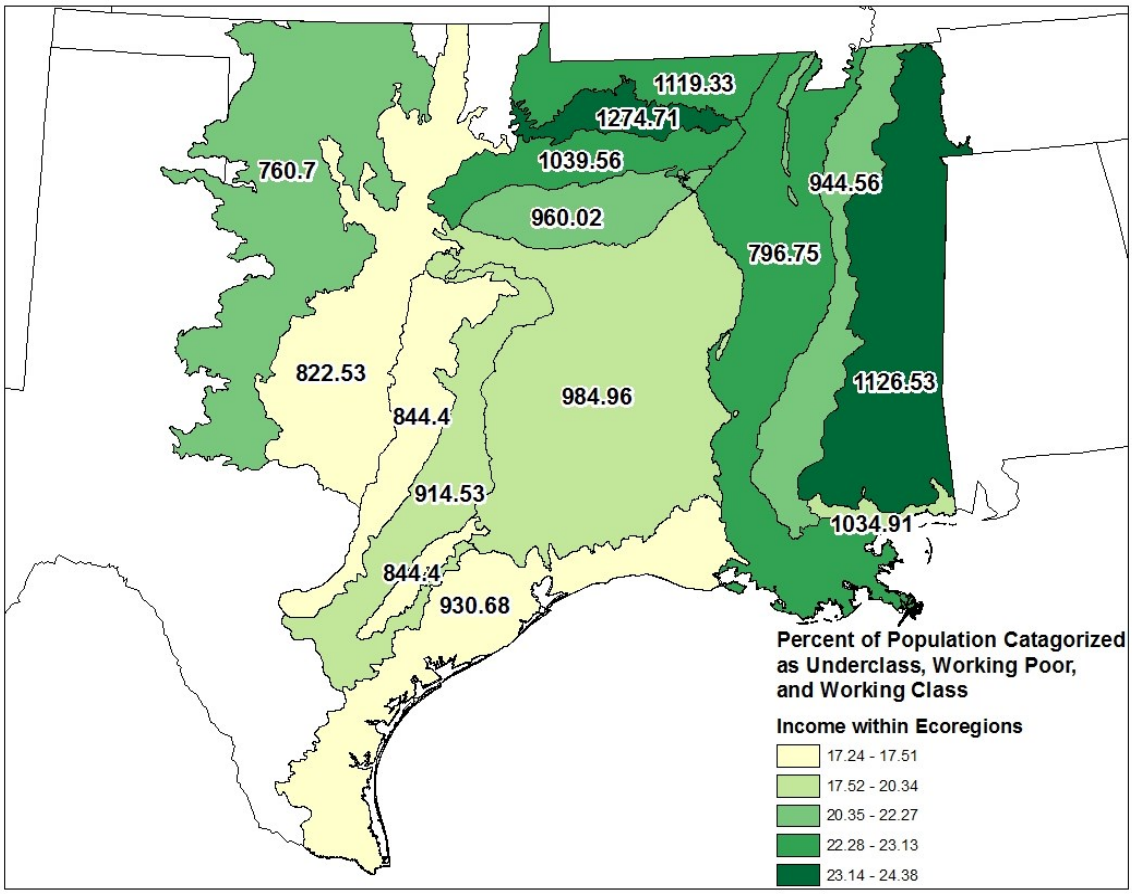

Figure 3: High Risk Income Levels within the Ecoregions. Lighter colors represent lower percentages of populations that are considered underclass, working poor, and working class and darker colors represent higher percentages. Labels show how many people in all three categories are within the ecoregions.

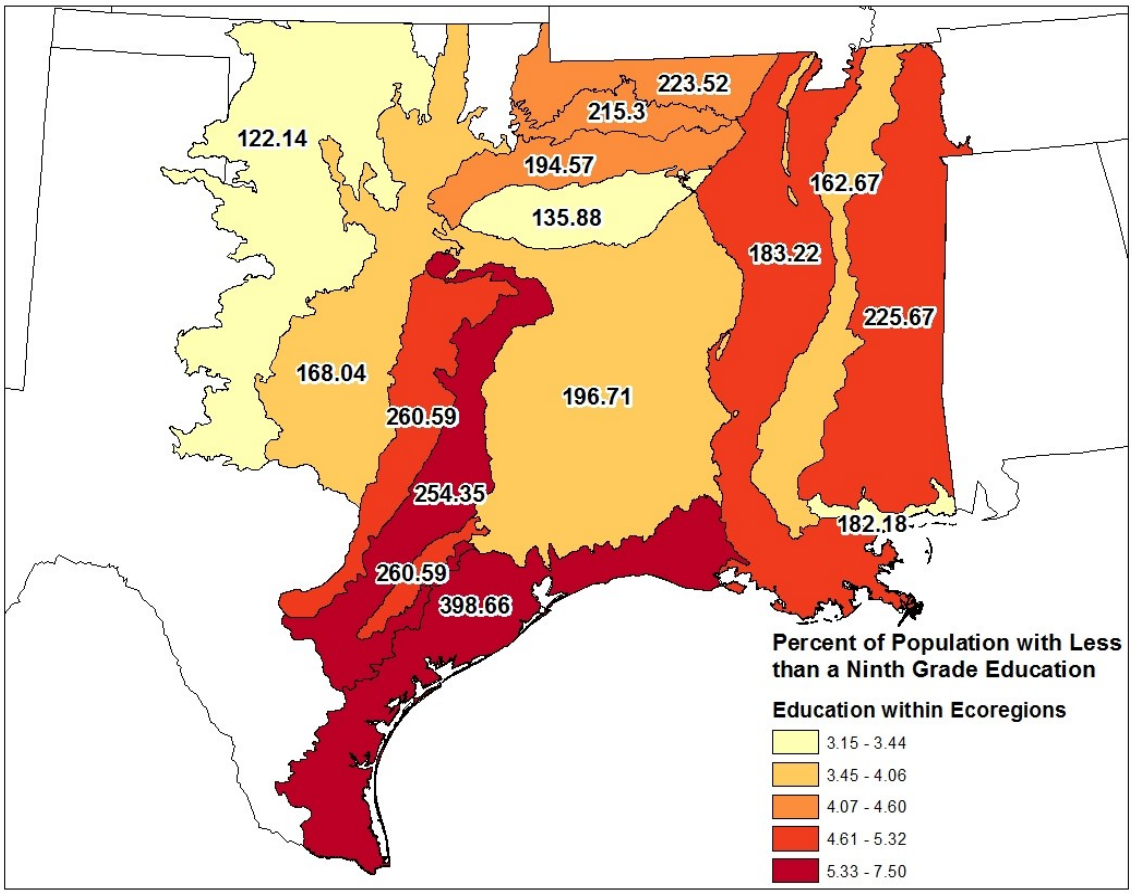

Figure 4: High Risk Education Levels within the Ecoregions. Lighter colors represent lower percentages of populations that have less than a high school education and darker colors represent higher percentages. Labels show how many people with less than a high school education are within the ecoregions.

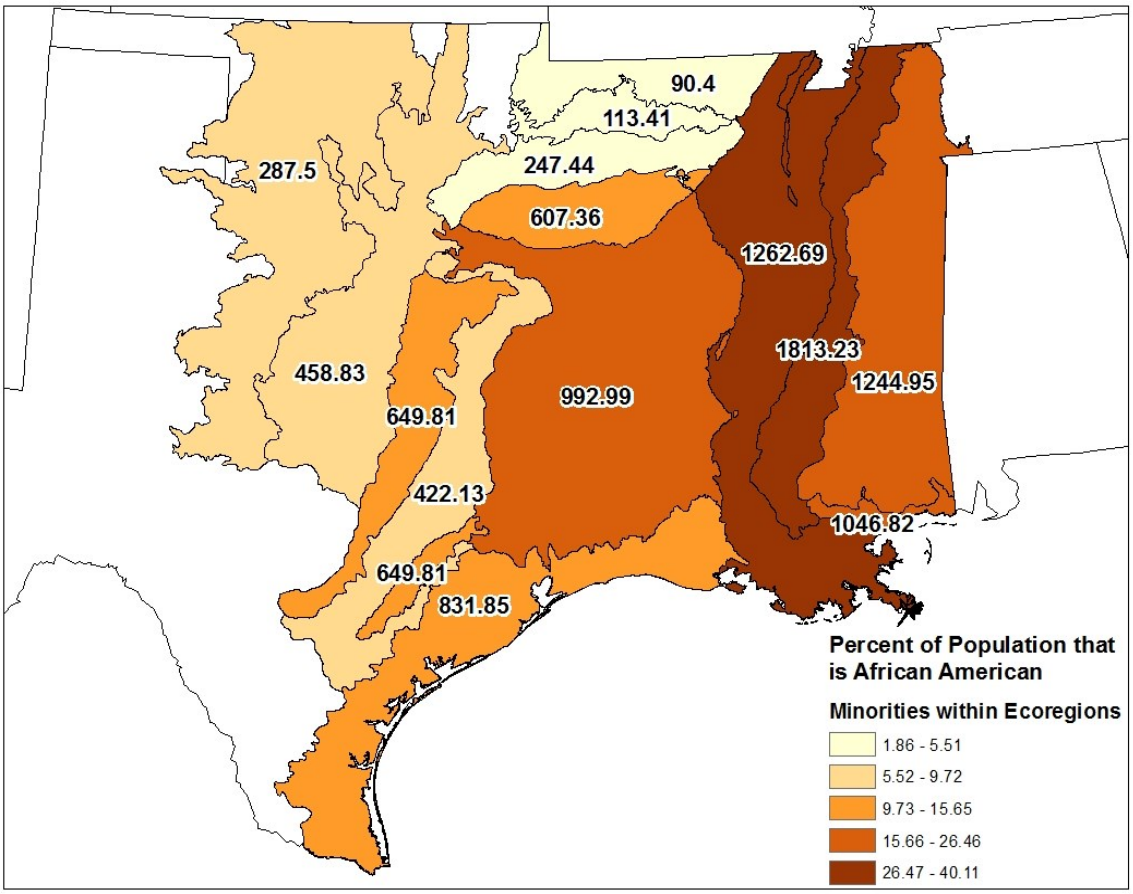

Figure 5: High Risk Ethnicities within the Ecoregions. Lighter colors represent lower percentages of populations that African American and darker colors represent higher percentages. Labels show how many African Americans are within the ecoregions.

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