The Use of Geospatial Information Systems in the Analysis of Pollution Trends in Southern Mississippi Region

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Abstract –In the last several decades, many cities in the United States continue to face the menace of environmental pollution at an alarming proportion with little use of geospatial technology and appropriate methods in dealing with the problem. The perverse nature of the problem not only threatens the different life forms in the environment, but it diminishes ecosystem quality and the livability of cities. While society tries to use policy to internalize externalities through taxes or prohibition, pollutants remain the most conspicuous examples of negative externalities. Compounding the matter is the absence of suitable tools such as Geographic Information Systems (GIS) for tracking the spatial dispersion of the quantity of pollutants and their impacts so that cities can have a better insight of the problems posed to their environment. At the same time, many cities lack complete inventory on the state of the environment in their areas. Apart from few studies, very little has been done to address the problem. The purpose of this study is to analyze the state of pollution and mapping of the trends within cities in the Southern Mississippi region of the United States. Emphasis is on the problems of air pollution, the source and the amount of pollutants, the consequences and the remedies. In terms of methodology, the paper uses descriptive statistics, correlation analysis and GIS to analyze the state of the environment and stressors within cities. While the results show that pollution activities have proliferated over the years in the region due to the growing presence of environmental stressors. A temporal spatial analysis using GIS to map the widespread discharge of chemical contaminants revealed a gradual spreading of stressors with risks to the sensitive coastal ecosystem. In the context of the region, GIS provides decision makers the capability for locating the quantity of pollutants and their impacts. The paper suggests the need for governments to enforce air quality standards and the adoption of methods for reaching those standards.

Key Words –GIS, pollution, pollutants, southern Mississippi, region, environment, remedies

I. Introduction

In the last several decades, many cities in United States including those in the Southern Mississippi Gulf coast region continue to face the menace of environmental pollution at an alarming proportion with little use of geospatial technology and appropriate methods in dealing with the problem. Taking a cue from Dennison (2007) notion of coastal environments as regions of strong gradients and major human impacts, the Southern Mississippi region has not only been sprawling with major developments but there are concerns as to whether the increased growth is impeding the region's air quality and the environment. In the area, pollution sources from the petro-chemical sector, power, and the agricultural industry operate within the vicinity of sensitive estuarine environments and metro areas inhabited by large populations.

Considering the severity of the ensuing impacts, most of the counties in the region rank highly nationally as some of the dirtiest in terms of environmental quality.

The perverse nature of the problem not only threatens the different life forms in the environment, but it diminishes the ecosystem quality and the livability of cities. This has created a situation whereby life support systems in the ecosystem are exposed to danger. Due to these anomalies, it is not surprising that governments have resorted to different types of policy instruments for a better management of natural resources (Doern, 1974). In the environmental field a vast majority of instruments under consideration include regulation, market or economic based incentives, voluntary mechanisms, permits, subsidies and taxation. Regulatory instruments are tools used by governments to control the activities of polluters through the enforcement of stricter standards during the process of production. While policy makers require industries to internalize environmental

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externalities through the imposition of taxes or prohibition and the use of polluter pay principles, pollutants remain the most conspicuous examples of negative externalities in areas such as the southern Mississippi region and other places.

Compounding the matter is the absence of suitable tools such as GIS for locating and appraising the quantity of pollutants and their impacts so that cities such as those in Southern Mississippi can have a better insight of the problems posed to their environment. Considering that many of those cities lack complete geospatial inventory on the state of the environment in their areas coupled with paucity of studies, very little has been done to address the problem. To overcome these difficulties, GIS has emerged as a vital tool for integrating geo-referenced data on pollution assessment. It is also a spatial system for the organization, storage, transformation, retrieval and analysis of data where location is important (DeMers, 1997; Aronoff, 1989). In fact, quite a number of GIS oriented approaches for forecasting the dispersion of chemicals are widespread in the literature (Schwetz et al., 1991).

Just as the visualization of pollution patterns in a map has now been optimized in the arena of public environmental health through GIS (Jerret, 2001), the capability to map pollution hazards geographically offers decision makers better clues on where to focus abatement measures. In addition to mapping externalities (Miller, 2001), decision makers can use the device to plot potential predictors and environmental quality inhibitors. Accordingly, several studies have mapped pollution concentrations (Burnnet et al., 2001, Jarrett 2001, Pikhart et al,. 1991, 2001); and socio-economic distributions of pollutants (Buzzelli et al., 2003; Jareet 2001. The spatial representation of pollution predictors in public policy helps one decide on target locations and the mechanisms for monitoring the outbreak of disasters. For more information on other researchers who integrated GIS with spatial statistics, see the work of Gatrell and Loytonnen (1998); and Jerrett et al. (2001). In light of these observations, part of the emphasis in various sections of the paper involves the mapping of potential stressors and pollution predictors in the study area.

II. Objectives and Organization

The purpose of this study is to analyze the state of pollution and mapping of the trends within cities in the Southern Mississippi region of the United States. Emphasis is on the problem of air pollution, the source and amount of pollutants, and ways of attaining environmental quality. In terms of methodology, the paper uses descriptive statistics, correlation analysis and GIS to analyze the state of the environment and stressors within cities. There is also an attempt to design a geospatial methodology for assessing the extent and location of pollutants and their quantity in the study area. The paper is divided in four parts. Part one covers the introduction and the background information with focus on the issues. The second part describes the study area and the methods. In part three, the results of temporal spatial data analysis highlighting the extent of environmental pollution are presented along with a geospatial analysis of the patterns of pollution dispersion in various locations. Part four offers a brief discussion of the findings with some lines of action for attaining pollution abatement and a concluding statement.

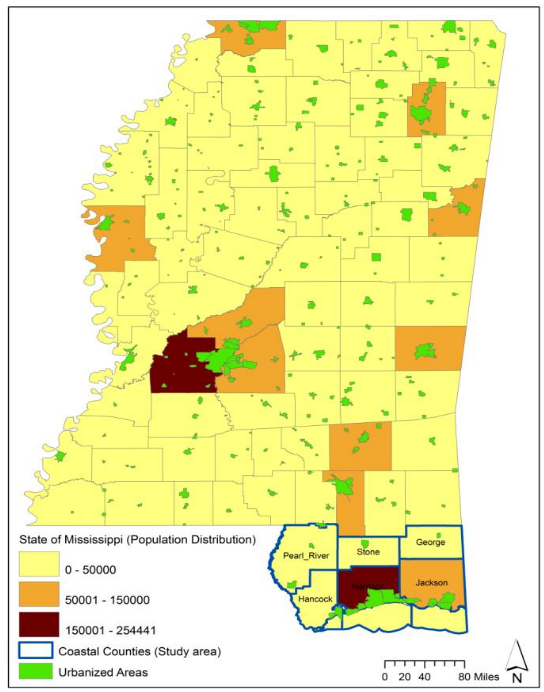

Fig. 1. The Study Area: Southern Mississippi region

III. Methods and Study Area

The study area located in Southern Mississippi along the coastal plains in the Southern portion of the map in Fig. 1 encompasses 6 selected counties. The map shows the state of Mississippi with population distribution of different levels and the spatial location of the urban areas and the delineation of coastal counties within the study area. The six counties under analysis consisting of Pearl River, George, Stone, Harrison, Hancock and Jackson have a combined population 437,408 in 2006 (Table 1). In recent years, three of the coastal counties of Southern Mississippi have experienced significant growth. In fact between 1950 through 1990, Hancock, Harrison and Jackson counties had a population growth of 168%, 96% and 276% respectively while George and Pearl River Counties each gained between 65% and 90%.

The study location which stretches through major urban areas along the Gulf coast region of Pascagoula and Biloxi-Gulfport metro areas shown in the Table, contains major thriving urban areas prone to severe pollution and other environmental problems. The major river basin, the Pascagoula is Mississippi's second largest basin measuring approximately 164 miles long and 84 miles wide. While, the basin drains an area of about 9,600 miles before emptying into the Gulf of Mexico. The Pascagoula is also the largest unimpeded major river system in continental United States. The major streams in the area include the Pascagoula, Leaf and Chickasawhay Rivers as well as the Black and Red Creeks (MDEQ and NRCS 2007). The total estimated land area of the watershed measures about 386,008 acres with non-irrigated cropland and pastureland as the major land-uses. About 72% of the basin contains forested area while the other 21% is classified as agricultural land.

With the presence of generally well-drained and moderately drained soil types, the basin contains about 542 farms and an average farm size of 94 acres. The size of cropland stretches across an area estimated at 22,100l acres coupled with an additional 20,800 total acres devoted to pastureland (NRCS 2007).

From an economic standpoint, timber use in the basin generates $325 million dollars to the economy. The Pascagoula basin produces 75% of oil and gas production in the state and there are about 250 surface mining operations in the area (Estes, 2006). With the recurring declines in agriculture and timber activities in the region in recent years, other forms of land use have increased their impact on the ecosystem. Although in channel mining was quite rampant in the area until it was banned in 1995. Floodplain sand and gravel mining remain active on the Bowie river side of the basin, as well as Thompson creek and Leaf River. During the same period, simultaneous development has been occurring in many parts of the basin, including the cities of Pascagoula, Moss Point, Meridian, Hattiesburg and Laurel (Mossa and Cooley, 2005; Estes, 2006).

<u>*Methods Used*</u>

This paper stresses a mix scale approach involving the use of descriptive statistics, and geospatial technologies of GIS in processing data provided through government sources and data bases from other organizations. This research also presents a methodology designed for use in situations where physical accounts, descriptive statistics and GIS analysis of the state of the environment within cities are not readily available. The raw spatial data made up of maps and other kinds of digital information used in the research came from the United States Geological Surveys (USGS) data procurement unit, the USDA and the US Environmental Protection Agency (EPA), the Government of Mississippi, the United States Census Bureau and other organizations such as the University of Maryland On line data unit.

<u>*Step 1: Data Acquisition*</u>

The first step involves the identification of the variables needed to assess the state of pollution among cities in the Southern Mississippi region of the United States. The spatial units of analysis consisted of the counties located in the Gulf region (Table1). The variables encompasses environmental data such as land cover elements (of the amount of fertilized farmland areas, impaired water bodies,) environmental releases from air, water, land, underground injection of pollutants, offsite transfer of pollutants and produced wastes. Others include pollution sources, their quantities and various miscellaneous pollution indicators (see Appendix). This process continued with the design of data matrices covering the various periods from the 1980s, 2000 and beyond.

In addition, to the design stage, access to databases and abstracts that are presently available within the Federal and state archives in Mississippi and the United States Geological Surveys (USGS), the United States National Aeronautical and Space Agency (NASA) and host of other entities quickened the search process. The spatial data was acquired from the USGS and the Mississippi Automated Resources Information System (MARIS). The Information obtained covered the Southern Mississippi region of Pascagoula-Biloxi Gulfport area for the separate periods of 1988 and 2004.

<u>*Step 2: Geo Spatial Data Acquisition and Processing*</u>

For the study area of Southern Mississippi region, multi-temporal spatial data made up of shape files and maps were obtained for the study. The data that were assembled for the Southern Mississippi urban counties of Stone, Pearl River, Harrison, Hancock, George, and Jackson include pollution emission and ecological data. Others include shape files, paper and digital maps between 1988 through 2004. All the spatial and temporal data were analyzed using ARCVIEW and SPSS. The outputs ranged from texts, tables and maps as well as matrices.

The processed data displayed under different legends makes ecological variables like water, impaired areas and others appear as shades of blue and brighter reds indicating impaired watersheds while the other pollution emission indicators were distinguished in different colors as well. Furthermore, the output was visually compared with the trends evidenced in the area to see the extent of spatial dispersion across time and space along the tributaries of the Southern Mississippi Gulf coast environment. The remaining procedure involves spatial analysis and output (maps-tables-text) covering the study period using ARCVIEW GIS. This process helped show the extent of temporal-spatial evolution of environmental pollution predictors induced by industrial and development activities. This provided opportunities to undertake the sequential mappings of the stressors and pollutants impacting the stream environments of the South Mississippi region.

IV. Environmental Pollution Analysis

This part of the paper presents the results of the descriptive statistics and temporal-spatial analysis of pollution trends using GIS and correlation analysis on a set of indicators associated with environmental pollutants already outlined in the methodology. The effort here consists of the snapshot on a wide range of information focusing on various pollutants, fertilized areas and impaired waters and other variables in the region.

Temporal Analysis of the Nature of Environmental Toxics

At Pearl River County during the 12 year period of 1988 and 2002, the quantity of air pollutants discharged into the atmosphere by industries stood at 1,1903,364 pounds. Among the other indicators, the volume of total environmental releases, offsite transfers and total production of related wastes amounted to 1,211,356, 634,464 and 4,561,438 pounds during the same periods. Within the individual periods, the quantity of total environmental releases of pollutants estimated at hundreds of thousands of pounds reached significant levels during 1990 and 1992. Similar pattern of releases in the county consists of 244,116 in 1990, 229,101 by 1991, 129,386 in 1992 and 99,812 pounds in 1993. This was followed by additional pollutants estimated in tens of thousands that appeared from 1993 and 2002. In terms of pollutants from off sites, the largest transfers into the county occurred in 1992 and 1997 when the volumes ranged from 467,050 and 108,338 pounds respectively. The total production of related wastes not only reached the million mark of 1, 093, 397 in 1991, but it intensified further in the county with more wastes estimated in tens of hundreds of thousand pounds during the ensuing 11 years from 1992 -2002 (Table 2). George County as the table indicates seem to have negligible levels of pollutant releases when tallied and compared with the other counties (Table 3). As a result, there would be no extensive analysis of the trends in the county.

Between 1988 through 2002 at Stone county, the overall tally in the various categories of pollution indicators for the area consists of 193,486 pounds for air alone and about 195,233 pounds for combined environmental releases into air land and water. Among the other pollution categories, about 124,535 pounds came from offsite transfers while total production related wastes accounted for 335,956 pounds. In Stone county, the total discharge of environmental toxics were amazingly high between 1990 -1994 when the largest releases into the atmosphere ranged from 36,033 to 35,043 during 1990 through 1991. The volume of pollutants that were discharged in the air in the later years consists of 11,980 pounds in 1999, 13,066 in 2000, 14,740 in 2001 and 7,532 in 2002. At the same time, the total offsite transfers of pollutants which reached significant levels were in the order of 30,625, 32,384, and 34,793 in 2000, 2001 and 2002 respectively.

In the county, production related wastes varied from 38,896 in 1991, 28,406 by 1992 and 21,887 in 1994. In the later years, the fiscal year 2001 with 78,195 pounds emerged as the period stone county had more total production related wastes than ever. Even though the quantity of contaminants for the county was tallied in thousands of pounds, they were still lethal enough to inflict irreversible harm on the ecosystem and the residents of the area (Table 4).

For Harrison County as Table 5 shows, the volume of contaminants in the area appeared much higher than some of the other areas in the region. Note that in the county between 1988-2002, when the overall total from air releases was estimated at 84,761,839 pounds, about 375,269,624 pounds of pollutants were injected into the underground. With the sum of all environmental releases including the former and later categories estimated at 467,742,535 pounds, the quantity of offsite transfers and production of related wastes stayed at 6,379,769 and 431,514,796 pounds respectively. The quantity of pollutants in all the categories appeared in tens of millions from 1988 and 2002. While air releases ranged from 11,034,704 and 12,384,227 between 1999 and 2000, additional volumes of large releases in millions consists of 2,200,000 from land in 1988 and over 1 million pounds of land releases from the period 2000 through 2001. Note that the quantity of underground injection of toxins were initially all in tens of millions of pounds, but as time went on during 1988-1994 period, the county eventually emerged with far more larger volumes of toxins estimated at 40, 500,000 and 57,000,000 pounds.

In a similar vein, the total environmental releases for Harrison County reached its biggest level of 60,324,170 pounds during the 1994 fiscal year at a scale that surpasses the entire periods. In addition, to this, two offsite transfers measured at 1,136,491 pounds, and 1,215,912 occurred in both 1994, and 1997 while the quantity of the rest of the transfers in the remaining years of 1988-2002 stayed under hundreds of thousands. Production related wastes in high tens of millions were evident during 1991-1994 and all through 1997 to 2002 when the volumes were in the mid tens of millions. In this period, the largest volumes of produced waste were in the order of over 67,000,000 in 1992 to 1994 along with 51,752, 479 pounds that was audited in 1991 (Table 5) .

Hancock County in the various years was exposed to about 2,028,564 pounds in air pollutants, when tallied with the amount of toxics ravaging land and water, the total number came to 2,041,579 for the overall environmental releases. For the remaining indicators, as` the county took in 8,864,117 pounds from offsite transfers, production related wastes totalled 283, 873, 460 pounds from 1988-2002. In terms of the brake down among the individual years, the total environmental releases which appeared in hundreds of thousands came in the order of 707,554, 549,355, 204,610, and 101,509 pounds in 1988, 1989, 1990, and 2001. Even though the total offsite transfers in hundreds of thousands of pounds occurred at a higher frequency in the county between 1988-2001, the amount that the county received in the fiscal years of 1997 and 2002 still ranked higher at 1,386, 500 and 1,084,723 pounds respectively. From the Table see also that the total number of production wastes in the low millions were not only quite pronounced, but the county contained huge chunks of industrial garbage estimated between 48,447, 102 to over 75,000, 000 pounds in 1999, 2000, 2001, and 2002 (Table 6).

Turning to the county of Jackson, the table indicates large levels of contaminants with 59,453,969 pounds in overall volume of air release, 5,334,626 for water, and 5,769,513 in land toxics. Among these categories, about 5, 09,587 pounds are attributed to underground of injection of pollutants. With the entire environmental releases estimated at 71,067, 693, the county took in additional 257,458, 702 pounds from off site transfers while the industries were responsible for an estimated 1500, 677,084 pounds of waste. In each category of the indicators from air releases to underground injection of toxics, the county experienced colossal discharge of pollutants between 1988 through 2002. In as much as the total environmental releases during the 1988-2000 period seemed stable, those in the low or 1 millions occurred in 1989-1994 as environmental release measuring over 4 million pounds appeared more in 1990, 1988, 1992, 1993, and 1995.

The other evidence of this trend includes the volume of toxics estimated at 4,643,321, 4,858,459, and 6,394,074 in 1997, 1998 and 2000. The largest volumes consist of 5,466,125 and 5,443,863 that were produced in 1991 and 1996. In the later years of 2000 -2001, the total releases jumped to 6,394,214, and 6,280,962 pounds. Within this period, total off site transfers of pollutants in 1993 estimated in millions at 192,706,725 surpassed the other ones as the largest in that category. See also that in 1993-1998, when the total production waste were tallied in hundreds of millions, the 313, 088,808, and 204, 362, 692 pounds in waste streams in 1992 and 1998 exceeded those of the other periods under analysis (Table 7).

Fertilized Acreages of Agricultural land, Impaired Water Areas and List of Pollution Sources

In terms of the size of acreages of land treated with fertilizer, the counties of Pearl River and George appear to have exceeded the other areas in the use of fertilizer nutrients. The use of fertilizers in Pearl River ranged from about 32,262 acres in 1992, 28,907 during 1997 and 14,234 by 2002. Over the years (1992, 1997, and 2004) at George County, the area of agricultural land treated with fertilizer was estimated at 16,484, 11,907 and 19,395 acres. Within the same periods at Stone county, fertilizer acreages consists of 8,846 in 1992, 8,671 in 1997 and 8,886 in 2002. In 1992 about

3,530 acres were under the direct applications of fertilizer nutrients in Harrison County, in the following periods of 1997 and 2002, the size of fertilized areas stayed somewhat identical at 4,514 in 2002 and 4,323 in 2002. For Hancock County, land treated with fertilizers was estimated at 6,135 acres in 1992, 9,271 by 1997 and 7,062 during 2002. Between 1992, 1997 and 2002 in the Jackson county area, the numbers varied from 3,511 to 11,832 and 8,779 respectively (Table 2).

On the percentages of change, see that the counties were evenly split in terms of declines and gains in 1992 -1997. In fact, three counties (Harrison, Hancock and Jackson) made gains while three other areas most notably Pearl River, George and Stone and others saw their acreages of fertilized land decline. The breakdown of the figures showed that fertilized areas grew by 27 % at Harrison, 51% at Hancock and by 238 % in Jackson County. With the exception of the 62 % gains in fertilized areas for George and 2.4% for Stone county, the remaining four other counties experienced sizable declines in the period of 2002 through 2004 (Table 8).

On the other environmental variables, in 1998 impaired water areas appeared more in the South Mississippi urban areas with the three counties of Pearl River, Harrison, and Hancock each accounting for the 2 major water areas under impairment. In the same period, George and Jackson counties led the rest of the region with 5 impaired water areas while Stone emerged as the county with the least impaired water surface. Among the counties, in 2002 and 2004, only the George county and Hancock areas experienced water surface impairment in 2 areas while the rest had either one case of reported impaired surface or none at all (Table 8). From the list of pollution sources, as Tables 9 indicates, Jackson County, Harrison, Hancock and Stone appeared to have more pollution sources from various industries including petrochemical, mining power and utility companies. Among the counties, Jackson ranks 1st with 10 pollution sources or facilities, followed by Harrison at 2nd with 7 sources. Others include Hancock listed at 3rd with 4. The two other counties of Pearl River and Stone each had 3 sources while George county finishes with just only 2 (Tables 9).

V. Correlation Analysis

To buttress, linkages to the behavior of some of the variables herein analyzed in contributing to stream habitat pollution, the simple correlation analysis performed on selected variables shows a positive relation between impaired waters and fertilized acres. With this increase in fertilized acres, there came a major rise in the number of impaired waters as well.

<u>Spatial analysis on some of the indicators</u>

Turning to the level and severity of pollution in the region, see that the classes as represented in fig. 2 consist of four types such as highly polluted, polluted, moderately clean and clean up to 50. In terms of definition, highly polluted refers to areas on the map that experienced extreme forms of contamination while polluted denotes normal forms of it. Moderately clean and the clan classes on the map represent areas that experienced fairly and normal levels of cleanliness.

During the fiscal year of 2002, the geographic diffusion of pollution appeared highly pronounced in the coastal counties of Jackson, Harrison and Hancock. From the map, both Jackson and Harrison share similar clusters as the mostly highly polluted areas while Hancock emerged as a polluted county as well (Fig. 2).

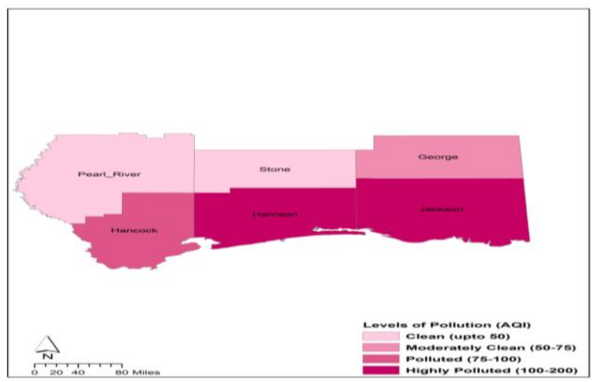

Fig. 2. Levels of Pollution 2002

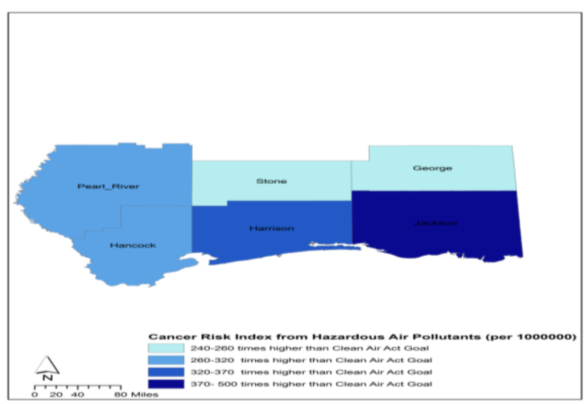

Fig. 3. Cancer risks from Hazardous air pollutants 2002

Pertaining to case risks from hazardous air pollutants represented in Fig. 3, the first classes (370-500 times and 330-370 times) refers to areas that were 300 -550 higher than the policy goals and threshold as required by the provisions of the US Clean air act. The same can be said of the second set of classes represented in the listed categories of 300-320 and 240-280. These are areas where the intensity of pollutants exceeded the permissible levels under the US Clean Air Act in terms of air quality. Even though the average individual added cancer risks from hazardous air pollutants are somewhat even, in 2002 among the counties, those around the coast and the lower part of the study area such as Jackson, Harrison, Hancock as well as Pearl River still ranked relatively higher in terms of risks per million in the region at levels much higher than the US Clean Air Act goals (Fig. 3).

In a place where percent changes in Toxic Release Inventory (TRI) release provides clues on the state of the environment, Fig. 4 helps identify the severity and the levels between 1988 to 2002 by showcasing the four different classes. The initial class of > 100% increases in TRI represents areas where the percentile level rose significantly by over 100%, while the 50-100 % increase in TRI release class refers to places on the map where they are only under 100% or medium. Note also the presence of the no change category involving the releases at a constant level followed by the over > 100 decrease category in which the release of TRI is in decline. The percentage of changes in the amount of TRI chemical releases between 1988-2002 shows a concentration of both high and medium (100 % > to 50-100%) increases clustered around the upper counties of George, Stone and Pearl River and alongside the coastal area of Jackson County. Under this indicator, the areas in the region classified as having high or 100 percent decreases in the chemical releases appear scattered in different patches around Harrison and Hancock counties (Fig. 4). The percent of surface water with reported problems with its four classes can be distinguished by the > 90% category representing impaired waters experiencing sizeable damages. There also those with damages classified under the 80-90% range along with 60-80% and < 60% levels of damages. The percentage of surface water in 2002 with reported pollution problems along the watersheds in the study area seemed rampant at various scales ranging from 60-90% and over (Fig. 5). With much of the problems concentrated in Stone and Harrison counties with 90% and over of the watersheds involved, Pearl River and Hancock counties on the other hand, also faced similar threats on 80 to 90% of their watersheds.

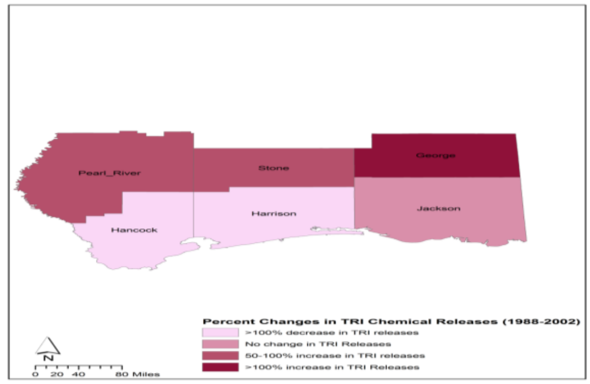

Fig. 4. Percent Changes in TRI releases (1988-2002)

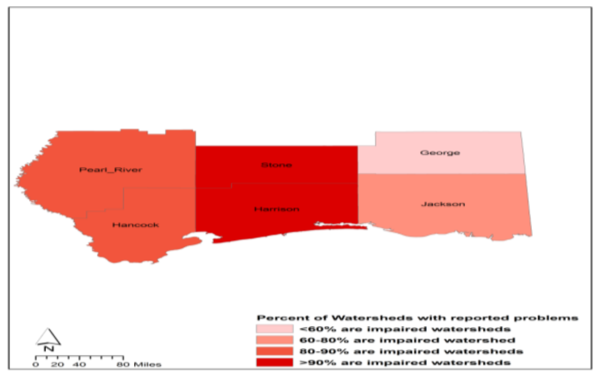

Fig. 5 Percent of surface waters with reported problems 2002

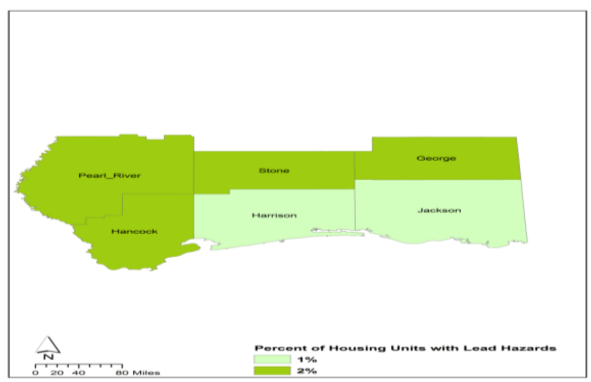

Fig. 6 Percent of housing units with lead hazards 2002

The percentage of housing units exposed to high risks of lead hazards in 2002 are defined by the 1% to 2% levels, with the later exceeding the former in the percentage category. Note that those presumed to be in the top 2 percent category seemed fully concentrated in 4 of the six counties mostly in the upper and lower part of the map. The exceptions are the counties of Harrison and Jackson both of which had 1 percent of their housing units under exposure to lead hazards (Fig.

6). The number of Toxic Release Inventory sites defined by four classes contains 7-10 group of TRI sites ranked as the highest numbers. This is followed by the medium types represented by 4-6 sites. The lower end of the TRI sites represents those having 2-3 and 1 TRI sites alone. In 2002, when large numbers of toxic release inventory sites were located in the various counties, Jackson County emerged with more sites (7-10) alongside the county of Harrison which had 4-6 of those sites. In the same period, the number of toxic release inventory sites in the other counties stood at 1-3.

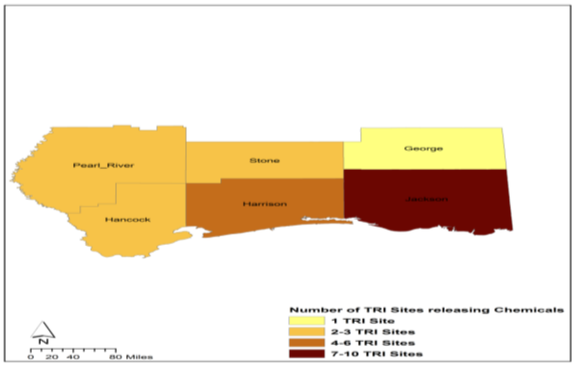

Fig. 7 Number of TRI sites releasing chemicals 2002

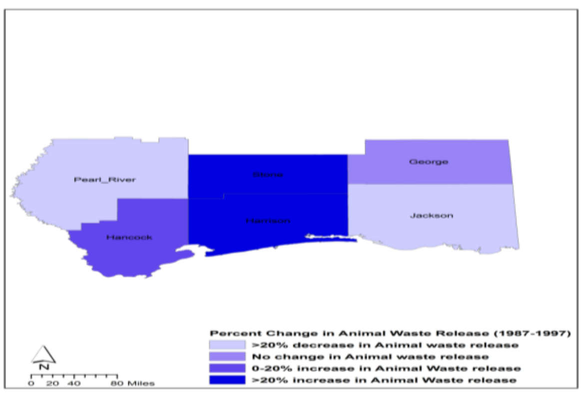

Fig. 8 Percent change in release of Animal waste (1987-1997)

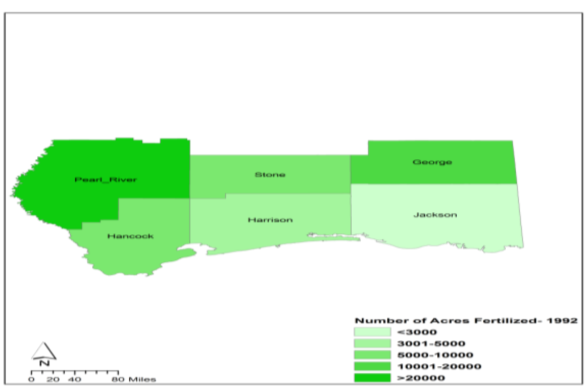

Fig. 9 Number of Acres Fertilized 1992

Pertaining to the spatial tracking of animal waste release in Fig. 8, it is defined by four classes of >20% increase and 0-20% increase in animal waste, no change in animal waste release and <20% decrease in animal waste release. The > 20% and 0-20% increase in animal waste stands as a measure of the high and medium rises in those two categories over time. The no change class refers to no variations while the <20% decrease in animal waste release stands for the extent of declines. See that the high, medium and low percent increases were evident in Stone, Harrison and Hancock counties with no changes in George County. Note also the decreases in animal waste release evident in Pearl River and Jackson counties between1987-1997 (Fig. 8).

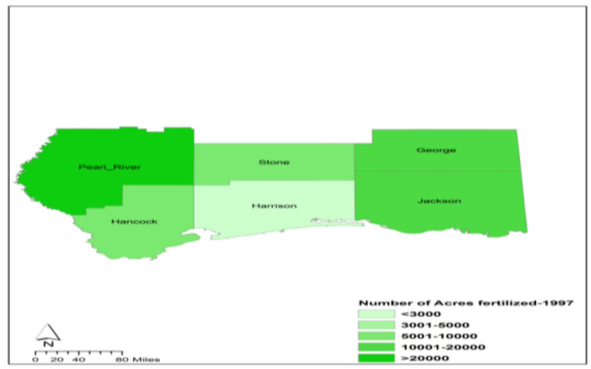

Fig. 10 Number of Acres Fertilized 1997

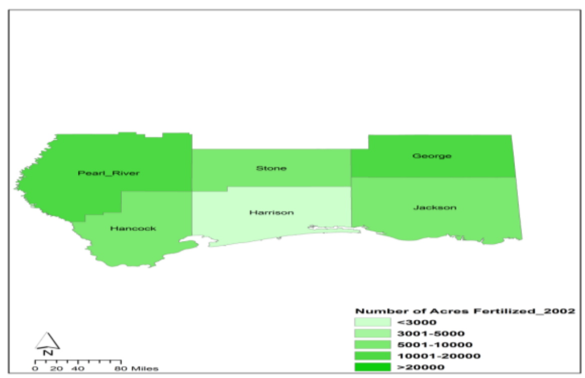

Fig. 11 Number of Acres Fertilized 2002

The spatial aspects of the indicators threatening streams such as the number of acres covered with fertilizer during the periods of 1992, 1997 and 2002 are represented in Fig. 9, 11 and 12 under four classes. In Fig. 9 to 12 the significant classes of >20000 acres to 10001 - 20000 represent the high number of acres treated with fertilizer. The medium class refers to the 5000 to 10000 acre types while the lower types consist of those classified as 3001-5000 coupled with the < 3000 category.

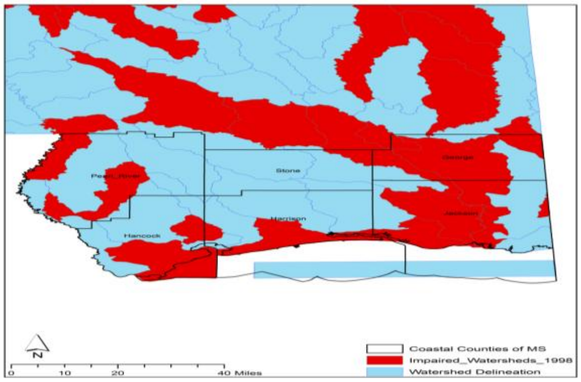

Fig. 12. Impaired Watersheds Due to Nutrient Flow 1998

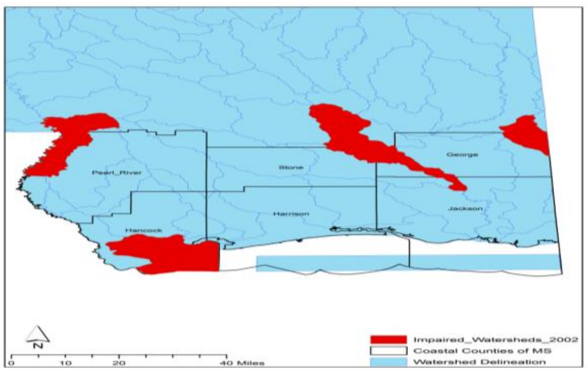

Fig. 13. Impaired Watersheds Due to Nutrient Flow 2002

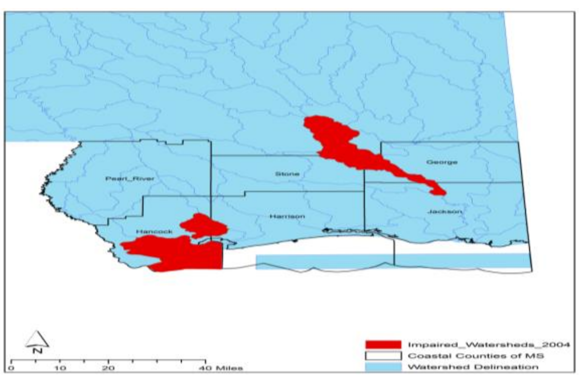

Fig. 14 Impaired Watersheds Due to Nutrient Flow 2004

The number of acres under fertilizer use across space as the map shows seemed quite pronounced in the periods of 1992, 1997 and 2002 in some counties. Note that the Northern portion of the study area map highlighting Pearl River County had fertilized areas exceeding 20000 acres. Fertilizer use not only reached high levels, but the Northern part appeared as the area with more fertilized areas in the 1992, 1997, and 2002 fiscal years (Fig. 9, 10, 11). The information on fig. 12 to 14 describe impaired watersheds, coastal counties and the watershed delineation. Impaired watersheds as shown in the figures stand for degraded watersheds, coastal counties are those geographic units located around the coast line while watershed delineation deals with demarcation around it. Turning to impaired watersheds from nutrient flow in the coastal counties, there was a high concentration of impaired water areas in the 1992 period with much of it located at George and Jackson, Harrison, Hancock and Pearl River. A closer look on the maps during the year 2002 and 2004 indicates a slight recurrence of impairment in minute clusters within the three counties most notably Hancock, George and Jackson (Fig. 12-14).

VI. Discussions

The snapshot of the discharge and transfer of various pollutants as wells as fertilizer application and the case of impaired waters and the presence of environmental stressors in the region show they pose serious threats to the surrounding ecology of the area. Regarding the environmental analysis, it is evident from the tables that the total amount of environmental contaminants in the study area reached sizable levels over the years (Tables 2-7). A case in point is the Pearl River county area where the quantity of air pollutants discharged into the atmosphere by industries stood at 1,903,364 pounds within the 12 year period of 1988 and 2000. Among the other indicators, the volume of total environmental releases, offsite transfers and total production of related wastes amounted to 1,125373, 634,464 and 4,561,438 pounds during the same periods (Table 2).

Another point worthy of note is that Stone County's total offsite transfers of pollutants which reached significant levels were in the order of 30,625, 32,384, and 34,793 in 2000, 2001 and 2002 respectively. All in all in the years under analysis, the six major counties of the region experienced high, medium and low levels of pollution large enough to severely alter the carrying capacity of an ecosystem already stretched beyond limits (Table 4). Even though in the various category of pollution indicators, smaller counties produced volumes of pollutants proportional to the number of sources in those areas. The three other counties of Jackson, Harrison, and Hancock accounted for the highest volumes of total environmental toxins that were released in the region. The quantity of these pollutants measured in tens, hundreds of thousands and hundreds of millions of pounds in wastes are lethal enough to degrade the environment (Table 5-7).

Of great concern in terms of policy and abatement is the degree to which large environmental releases from air, water, and land contaminants, underground injection of chemicals, off site transfer of pollutant and industrial production of wastes remain fully concentrated in the region (Table 2-5). Regarding the temporal distribution of fertilizer or agrochemicals, the application levels grew extensively in double digits at Harrison, Hancock, George, and by triple digits in Jackson. On the acreages of land treated with fertilizer, the counties of Pearl River and George appear to have exceeded the other areas in the use of fertilizer nutrients. The applications of fertilizers in Pearl River ranged from about 32,262 acres in 1992, 28,907 during 1997 and 14,234 by 2002. Over the years (1992, 1997, and 2004) at George County, the area of agricultural land covered with fertilizer was estimated at 16,484, 11,907 and 19,395 acres respectively (Table 8).

On the percentages of change, see that the counties were evenly split in terms of declines and gains in 1992 -1997. In fact, three counties (Harrison, Hancock and Jackson) made gains while three other areas most notably Pearl River, George and Stone and others saw their acreages of fertilized land decline. In the fiscal year of 1998, impaired water areas seemed more frequent in South Mississippi urban areas. In that period, other counties most notably Pearl River, Harrison, and Hancock experienced impairment in 2 major water areas. The same can be said of 2002 and 2004 when George and Hancock each had similar numbers in impaired water areas (Table 8). On pollution sources among the counties, see that the petrochemical, power and utility industries operating in the area emerged as some of the largest contributors (Table 9). A simple correlation analysis performed on selected variables shows a positive relation between impaired waters and fertilized acres of farmland to show interconnectedness.

The study area also experienced the effects of several other miscellaneous pollutants that are hazardous to the region's environment (see Appendix). The potential impacts mostly impairment of watersheds, rising number of impaired water bodies, the flow of fertilizer run off and nutrients into sensitive stream habitats of the area raises the risks of ecosystem degradation and pollution. The perverse nature of the problem not only threatens the different life forms in the environment but it diminishes ecosystem quality and livability of cities in the large metro areas of Southern Mississippi coastal environments.

A temporal spatial analysis using GIS to map the widespread discharge of chemical contaminants revealed a gradual spreading of pollutants, elevated risks to the sensitive coastal ecosystem and exposure to cancer risks for residents of the area. There exists also enormous geographic diffusion of animal wastes in some of the counties where quite a number of houses have come under high risk exposures to lead hazards. In the context of the region, GIS provides decision makers the capability for locating and appraising the quantity of pollutants and their impacts.

Public policy will benefit more from the adoption of remedies geared at improving environmental quality through the enforcement of standards and the use of efficient abatement techniques to contain pollution. Some of the remedies should include strengthening existing policies, disclosure of emission sources, funding assistance, the design of emission information system and data infrastructure.

The thing to draw from the tabular analysis is that the pollution trends herein identified and the widespread use of fertilizers and the threats faced by the watersheds in the region do not operate in a vacuum. The emerging stressors and pollutants known to impact the environment are driven by industrial activities, agricultural farming and human presence. The fact that the sources of these pollutants are induced by human factors does re-echo the human nature interface debate that has lingered on in theoretical circles over the years. Highlighting the extent of this interface, in the context of the study area of Southern Mississippi region and the pollution threats, stands as a major contribution to the literature.

Theoretical Importance

The paper reaffirms the theory of human interactions with nature. Humans depend on nature for several things ranging from survival to the livability of communities. Currently, there seems to be a growing concern about the impact of economic activities on the environment and the rate at which industrial activities overstretch the capacity of natural systems to provide services as shown in Southern Mississippi. The sequential mapping and appraisal of the emerging stressors and their locations using GIS can serve as effective decision support tool for managers and communities in Southern Mississippi craving for a livable environment. With the growing stress inflicted on ecosystems, ecological consciousness has created a need for analyzing the interfaces existing among the various segments of the economy and the environment spatially.

In this setting, comprehensive pollution analysis for ecosystem protection is regarded by most managers as a necessary complement to effective environmental decision. Whether the goal is pollution prevention or some broader notion of sustainability, there is a widespread belief that sequential mapping of the stressors will help polluters identify and implement desirable environmental innovations. Moreover, environmental regulation is evolving toward public policies that rely mostly on the collection and reporting of environmental information anchored in pollution analysis and mapping of the stressors based on an understanding of nature –human interface debate.

There are also several important theoretical observations that have emerged in this study. Since the gradual acceptance of GIS as visualization tool for mapping the impacts of human nature interface in the public environmental health arena, pollution analysis as presented in this paper has continued to play a vital role by encouraging the adoption of theoretical tools for strengthening policy making. Given its current importance, human nature interaction theory, as conceptualized in the project, provides planning and policy the abundance of learning tools for enriching the intellectual and philosophical orientation of those attuned to theory and practice. This can go a long way in making the professionals promote the role of theories of human nature interaction as a road map to strengthening policies pertaining to pollution prevention. This theoretical revival brought about by GIS applications as a vital tool stems partly from the global call to action towards the adoption of spatial technologies in analyzing the impacts of human nature interaction in fragile environments.

In that regard, the ideas shaping GIS applications in pollution trends, as presented in the paper helps stimulate the interest and opportunities that are currently driving the course of research in environmental change. Additionally, the theoretical underpinnings of human-environment interaction have also widened the methodological options for planning. They are essential in addressing the ecological problems central to good decision making and for improving the treatment of nature during industrial activities. The familiarity with devices such as GIS in showing spatial patterns of various stressors associated with pollution continues to show promise. It remains germane in tracking the externalities from industrial activities spatially and their impacts on the natural environment. This can set the stage for continuous use of these approaches in future studies. The models used here can also be instrumental in encouraging the adoption of spatial technologies in identifying patterns of ecosystem disturbance and mitigation measures. They are relevant for planning in coastal environments such as the South Mississippi region. The methodology of this project can be used to sustain future research in the mapping of stressed environments and the ongoing human-nature interface debate.

The Benefits of GIS Methodology

The GIS mapping highlighted the spatial distribution of pollution indicators and the close proximity between sites of pollution and a fragile costal environment of the state as well. In the current study, the availability of temporal spatial data and analysis played a vital role in facilitating the assessments of the ecological risks emanating from industrial activities. The assemblage of the information and analysis using the mix scale methodology as an emerging science devoted to the study area, not only quickened the data processing stage of the study, but it unveiled the location of stressors in the South Mississippi region. It is essential for effective management and timely mitigation.

Accordingly, GIS analysis in this paper as a contribution the literature, stands as a relevant decision support tool for pinpointing high risk areas and watersheds threatened by environmental externalities. In the study area, this involved the generation of maps that identified externalities such as animal wastes, TRI sites, lead hazards, cancer risks, and surface water impairment. Visualizing metro areas and natural features prone to ecological stress in these settings, not only helped focus the scope of GIS and environmental planning with records of change in affected areas, but it furnished information on the pace at which industrial activities impact nature.

For the purposes of planning, spatial analysis offered a visual documentation of the state of the environment at precise locations on different sets of variables related to industrial activities in Southern Mississippi. With the capability to generate temporal spatial information, this perspective serves the needs of decision makers in weighing the significance of the emerging patterns and the impacts on the local ecosystem. Without access to such information, planners run the risk of offering improper blue prints and solutions for protecting the environment. GIS applications, can be effective as part of an emerging science for addressing these concerns by providing managers a yardstick for analyzing different levels of changes in the ecosystem. It is expected that they will serve a useful purpose in subsequent research and will evolve further through utilization in a variety of situational settings in the study area and elsewhere under conditions that are compatible with the ideas of environmental planning.

The study also serves as a conduit for future applications in the coastal areas of states or regions. This then stimulates the growth of regional expertise and confidence which in turn enhances the capacity to make decisions in areas associated with industrial activities and ecosystem impacts. This role of GIS as decision support tool, can lead to a real consensus as more users, and those in charge of policy making have faith in the approaches and make a conscious decision to increase their application in future. The applications of this technique in the research along with the findings from it therefore make a contribution to our understanding of GIS applications in the mitigation of pollution and environmental analysis. These techniques play a fundamental role with the steps upon which impact analysis of pollution activities is built. The project has revealed the utility of GIS applications in environmental planning and pollution mitigation and thus serves as conduit for future applications as an emerging science in communities impacted by pollution activities.

VII. Conclusion

Temporal-spatial tracking of pollution sources in the region point to heavy involvement of industrial activities in the petrochemical sector, power, utilities,agriculture and others. The perverse nature of the problem not only threatens the different life forms in the environment, but it diminishes ecosystem quality and the livability of cities.

Using geospatial technology of GIS, the paper shows that human-environment interaction involving pollution intensive industries in the Gulf Coast region fuels the concentration of several chemical elements lethal enough to inhibit sensitive estuarine ecosystem of the area. Compounding the matter is the impact of current practice of underground injections of pollutants, off site transfers, production related waste and fertilizer use in the areas. Ecological stressors made up of fertilizer applications, number of impaired watersheds, and pollution inventory sites were on the rise especially in areas adjacent to stream corridors. The pressures unleashed from these pollution variables as the analysis shows puts enormous strain on the region's air and water quality. All these raised the level of stress on the region's environments.

The GIS mappings highlighted the spreading of housing units exposed to the risks of lead hazards and the severity of pollution. The mappings also indicated the geographic diffusion of cancer risks from several stressors such as hazardous air pollutants, chemical releases and surface water with reported pollution problems along the watersheds. Other aspects of the GIS analysis highlighted the spatial diffusion of toxic release inventory sites and the location of animal waste release. The mapping of pollution predictors in environmental planning in those settings can assist in determining critical areas. This can enhance the monitoring and the introduction of pollution abatement programs in affected counties along the Southern Mississippi region. The study also highlighted the theoretical essence of the research and the importance of GIS. As part of the remedies, the paper offered six recommendations: strengthening existing policy, disclosure of emission sources, funding assistance; design of geo emission information system and the development of adequate data infrastructure, requiring government enforcement of air quality standards and the design of new methods for reaching them.

Finally, the expectation is that familiarity with devices such as Geographic Information Systems remains pertinent in showing spatial patterns of various stressors associated with pollution. They are vital tools for locating industrial activities fuelling recurrent externalities and their impacts on the natural environment. This can set the stage for continuous use of these approaches in future studies and education. The models used here can also be instrumental in encouraging the adoption of geospatial information technologies in identifying patterns of ecosystem disturbance and mitigation measures. They are relevant for resource planning in coastal environments such as the South Mississippi region.

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Table 1. The Study Area of Southern Mississippi Region

County	Population	Area in Square Miles	CMA
Pearl River	57,099	811	Picayune
George	21,828	478	Pascagoula,
Stone	15,608	445	Gulfport-Biloxi,
Harrison	171,875	580	Gulfport-Biloxi,
Hancock	40,421	476	Gulfport-Biloxi
Jackson	130,577	726	Pascagoula
Total	437408	3516	NA

Source: US Census Bureau

Table 2. Environmental Releases For Pearl-River County

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	8,864	12,850	0	0	21,714	2,208	NA
1989	41,351	5,600	0	0	46,951	13	NA
1990	243,016	1,100	0	0	244,116	43	NA
1991	229,101	0	0	0	229,101	467,050	1,093,397
1992	129,386	0	0	0	129,386	1,860	415,853
1993	99,312	500	0	0	99,812	3,865	326,423
1994	65,428	430	0	0	65,858	7,207	409,273
1995	65,923	0	0	0	65,923	10,607	337,878
1996	60,724	12	0	0	60,736	5,207	321,317
1997	47,845	0	0	0	47,845	108,338	268,801
1998	40,921	0	0	0	40,921	9,248	336,564
1999	22,965	0	0	0	22,965	6,337	248,065
2000	17,991	0	0	0	17,991	2,399	213,027
2001	18,225	0	0	0	18,225	2,748	293,663
2002	99312	500	0	0	99812	7334	297177
Total	1190364	20992	0	0	1211356	634464	4561438

Source:www.scorecard.org

Table 3. Environmental Releases For George County

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	250	0	0	0	250	750	NA
1989	750	0	0	0	750	0	NA
1990	765	0	0	0	765	44,499	NA
1991	0	0	0	0	0	8,501	426
1992	0	0	0	0	0	13,000	426
1993	0	0	0	0	0	22,500	8,300
1994	0	0	0	0	0	11,751	100
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	5,250	0
1998	0	0	0	0	0	0	0
1999	0	0	0	0	0	2,175	0
2002	18195	0	1500	0	19695	2750	19695
Total	19960	0	1500	0	21460	111176	28947

Source: www.scorecard.org

Table 4. Environmental Releases For Stone County

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	290	0	0	0	290	6	NA
1989	583	0	0	0	583	4,507	NA
1990	36,033	0	0	0	36,033	5,455	NA
1991	35,043	0	0	0	35,043	1,013	38,896
1992	25,036	0	0	0	25,036	708	28,406
1993	18,026	651	0	0	18,677	213	21,887
1994	16,023	256	0	0	16,279	75	18,492
1995	8	49	0	0	57	104	3,706
1996	4,218	24	0	0	4,242	778	13,337
1997	3,118	43	0	0	3,161	2,712	7,975
1998	8,519	25	0	0	8,544	4,765	16,066
1999	11,919	61	0	0	11,980	6,397	22,307
2000	13,014	52	0	0	13,066	30,625	43,677
2001	14,463	230	17	0	14,710	32,384	78,195
2002	7193	260	79	0	7532	34793	43012
Total	193486	1651	96	0	195233	124535	335956

Source: www.scorecard.org

Table 5. Environmental Releases For Harrison County

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	6,937,589	13,463	2,200,000	40,500,000	49,651,052	28,942	NA
1989	6,167,790	11,660	0	37,000,000	43,179,450	46,052	NA
1990	6,091,461	11,766	2,015	33,000,000	39,105,242	31,867	NA
1991	6,335,430	3,985	520	41,000,000	47,339,935	137,909	51,752,479
1992	4,200,325	6,435	2,670	52,000,000	56,209,430	296,664	63,522,706
1993	3,154,506	10,700	2,314	56,000,000	59,167,520	544,148	67,439,661
1994	3,313,910	7,850	2,410	57,000,000	60,324,170	1,136,491	67,566,902
1995	2,307,300	5,162	0	0	2,312,462	994,206	8,479,587
1996	2,191,060	535	4	0	2,191,599	801,371	9,760,053
1997	2,165,067	15	0	8,448,000	10,613,082	1,215,912	19,134,816
1998	8,471,453	4,575	666,934	6,880,000	16,022,962	308,598	25,738,073
1999	11,034,704	4,060	770,612	8,235,100	20,044,476	247,959	27,984,699
2000	12,384,227	6,020	1,015,125	12,557,081	25,962,453	248,485	34,816,983
2001	5,669,347	12,710	1,432,377	11,035,253	18,149,687	264,979	29,039,834
2002	4337670	1124	1505911	11614190	17469015	76186	26279003
Total	84761839	100060	7600892	375269624	467742535	6379769	431514796

Source:www.scorecard.org

Table 6. Environmental Releases For Hancock county

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	705,054	1,500	1,000	0	707,554	286,936	NA
1989	544,525	1,080	3,750	0	549,355	746,498	NA
1990	222,262	83	2,265	0	224,610	646,542	NA
1991	19,412	35	1,770	0	21,217	370,064	1,322,162
1992	16,718	0	0	0	16,718	254,963	1,021,113
1993	14,060	5	0	0	14,065	180,172	619,796
1994	22,194	5	0	0	22,199	345,947	1,003,482
1995	20,500	5	0	0	20,505	640,760	1,142,650
1996	48,517	255	0	0	48,772	460,685	999,467
1997	11,600	0	0	0	11,600	1,386,500	1,172,010
1998	79,668	20	0	0	79,688	506,205	1,189,576
1999	86,495	30	0	0	86,525	601,730	48,447,102
2000	84,148	35	0	0	84,183	586,587	75,321,377
2001	101,189	320	0	0	101,509	767,805	75,424,892
2002	52222	857	0	0	53079	1082723	76209833
Total	2028564	4239	8785	0	2041579	8864117	283873460

Source: www.scorecard.org

Table 7. Environmental Releases For Jackson County

Year	Air releases	Water releases	Land releases	Underground injection	Total Environmental releases	Total Off-site transfers	Total production-related waste
1988	4,271,088	248,275	153,464	3,000	4,675,827	4,744,023	NA
1989	3,072,412	868,931	5,881	3,000	3,950,224	488,331	NA
1990	3,561,912	656,375	17,331	1,000	4,236,618	315,389	NA
1991	4,551,134	903,012	10,172	1,807	5,466,125	4,078,875	80,494,344
1992	3,971,706	479,536	131,201	2,737	4,585,180	3,017,425	128,962,604
1993	3,762,441	367,659	132,217	52,872	4,315,189	192,706,729	313,088,888
1994	3,021,242	43,777	133,198	32,511	3,230,728	2,385,115	152,541,845
1995	3,808,062	85,200	151,898	82,251	4,127,411	2,041,550	156,270,179
1996	4,921,966	271,061	167,521	83,315	5,443,863	2,355,768	151,772,674
1997	3,904,709	360,494	281,477	96,641	4,643,321	5,891,740	166,186,058
1998	3,278,623	455,566	1,111,764	12,506	4,858,459	5,635,490	204,362,692
1999	3,577,822	191,648	432,834	91,662	4,293,966	10,013,832	39,959,773
2000	4,521,319	144,478	1,693,640	34,637	6,394,074	10,984,308	38,766,701
2001	5,312,888	87,997	868,430	11,648	6,280,962	7,478,798	38,722,031
2002	3916645	170617	478485	0	4565746	5321329	29549295
Total	59453969	5334626	5769513	509587	71067693	257458702	1500677084

Source: www.scorecard.org

Table 8. The Distribution of Fertilizer Use and Impaired Waters In Southern Mississippi Counties

Acres Fertilized					
Counties	1992	1997	2002	% Change(1992-1997)	% Change(1992-2002)
Pearl River	32262	28,907	14,234	-10.39	-50.75
George	16,484	11,907	19,395	-27.76	62.88
Stone	8846	8,671	8,886	-1.978	2.47
Harrison	3530	4,514	4,323	27.87	-4.23
Hancock	6135	9,271	7,062	51.11	-23.82
Jackson	3511	11,882	8,779	238.42	-26.11
Impaired Water areas					
Counties	1998	2002	2004	% Change(1998-2002)	% Change(2002-2004)
Pearl River	2	1	0	-50	-100
George	5	2	1	-60	-50
Stone	1	1	1	0	0
Harrison	2	0	0	-100	
Hancock	2	1	2	-50	100
Jackson	5	1	1	-80	0

Source: www.scorecard.org

Table 9. Pollution Sources in the southern Mississippi Counties

Source Pollutant	Location	Pounds of chemicals released	% contributed to the total release
Valspar Refinish InC.	Picayune (Pearl River County)	10021	72.46
Pearl River wood L.L.C.	Picayune (Pearl River County)	2939	21.25
Arizona Chemical Co. Picayune	Picayune (Pearl River County)	869	6.28
American Tank & Vessel Inc.	Lucedale (George County)	18195	92.38
Tri-State Pole & PIling Inc.	Lucedale (George County)	1500	7.616
Desoto Treated Materials Inc.	Wiggins (Stone County)	7277	96.61
International Paper Co.	Wiggins (Stone County)	135	1.79
Hood Inds. Inc.	Wiggins (Stone County)	120	1.59
Dupont Delisle Plant	Pass Christian (Harrison County)	14894376	85.26
Mississippi Power Co. Plant Watson	Gulfport (Harrison County)	2329539	13.33
Hartson-Kennedy Cabinet Top Co. Inc.	Gulfport (Harrison County)	200490	1.147
Ershigs Biloxi	Biloxi (Harrison County)	21172	0.12
LightHouse Marble	Biloxi (Harrison County)	20680	0.11
Taber Metals Gulfport L.P.	Gulfport (Harrison County)	1654	0.01
Northrop Grumman Ship Sys. Inc. - Gulfport Ops.	Gulfport (Harrison County)	1104	0.01
Wellman OF Mississippi Inc.	Bay Saint Louis (Hancock County)	27508	51.82
GE Plastics	Bay Saint Louis (Hancock County)	14985	28.23
NASA John C. Stennis Space Center	Stennis Space Center (Hancock County)	10011	18.86
Polychemie (Port Bienville Plant)	Pearlington (Hancock County)	575	1.083
Mississippi Power Co. Plant Daniel	Escatawpa (Jackson County)	1783848	39.07
Chevron Prods. Co. Pascagoula Refy.	Pascagoula (Jackson County)	1254077	27.46
Mississippi Phosphates Corp.	Pascagoula (Jackson County)	1137379	24.91
Northrop Grumman Ship Sys	Pascagoula (Jackson County)	306243	6.7
First ChemicaL Corp.	Pascagoula (Jackson County)	34792	0.76
Omega Protein Inc.	Moss Point (Jackson County)	23129	0.5
Ferson Optics Inc.	Ocean Springs (Jackson County)	13680	0.29
Shipley Co. - Moss Point P lant	Moss Point (Jackson County)	8932	0.19
Rolls-Royce Naval Marine Inc.	Pascagoula (Jackson County)	2222	0.048
Automatic Processing Inc.	Moss Point (Jackson County)	1445	0.03

Source: www.scorecard.org

APPENDIX I

Table: Miscellaneous Environmental indicators (*per 1,000,000)

County	Levels of Pollution	Percentage changes in TRI releases	Percentage of housing nits with lead hazards	Number of TRI sites releasing chemicals	*Cancer risks from Hazardous air pollutants	Percent of surface waters with reported problems	Percent change in release of Animal waste
Pearl_River	20%	-31%	2%	3	300	86%	-21%
George	30%	77.78%	2%	1	240	63%	-4%
Stone	20%	24.97%	2%	3	260	95%	17%
Harrison	100%	-65%	1%	6	370	100%	21%
Jackson	100%	-1%	1%	10	500	79%	-20%
Hancock	70%	-92%	2%	3	320	85%	13%