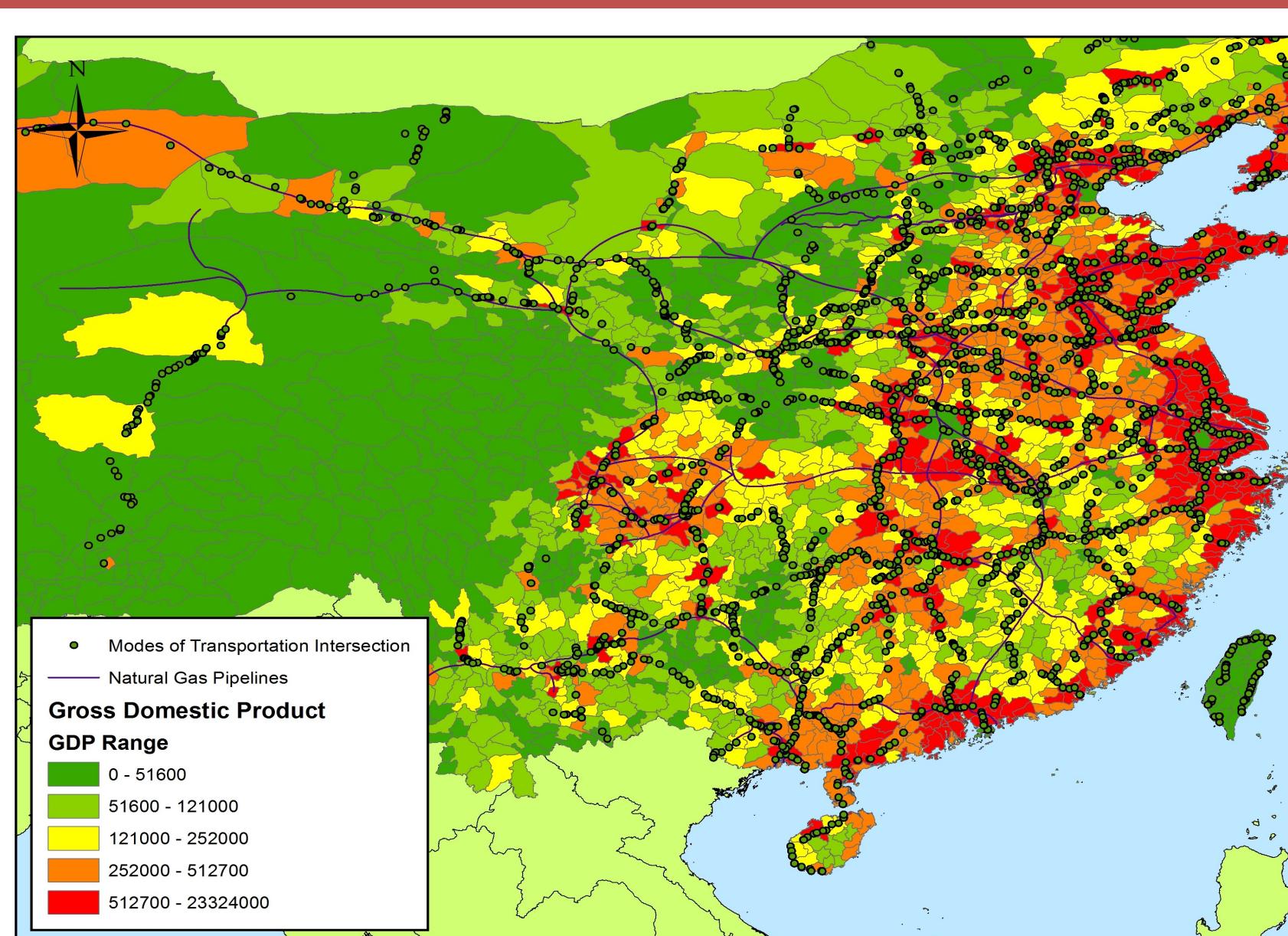


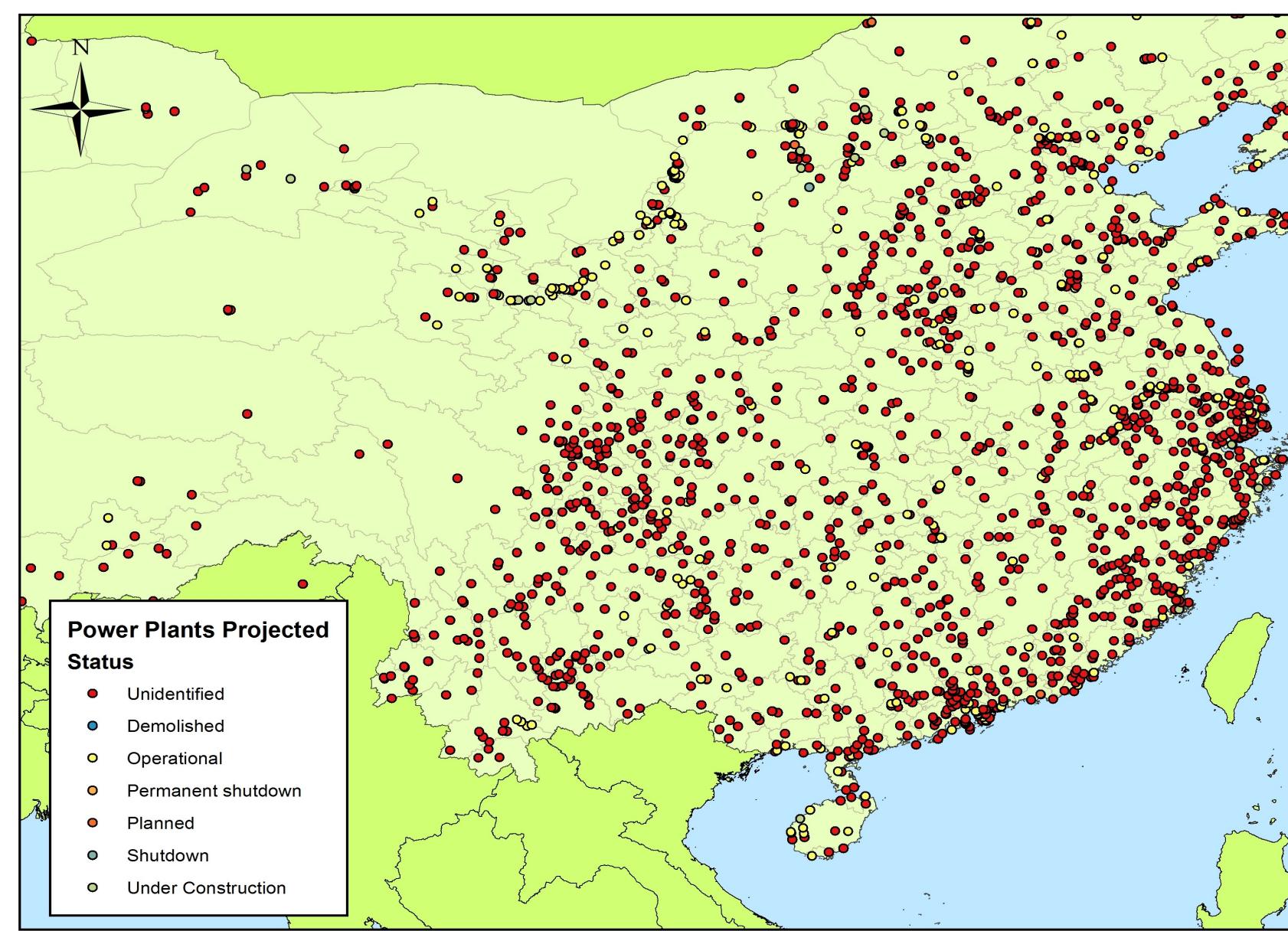
## Modes of Transportation



## Gross Domestic Product Correlations



## Power Plant Classification



## Explorative Study of High Particulate Matter Cities in China Tufts UNIVERSITY School of Engineering

## Introduction

China is home to nearly 1.4 billion people (roughly a 1/5 of the world's population) with a little more than half living in urban areas. China has industrialized more in a shorter period of time than any other country, positioning them as one of the leading manufacturers in the world and giving them leverage against other nations. Yet, the benefits of industrialization has come at a cost, the quality of life for the many people living in the urbanized areas. The main reason for this effect is the poor air quality that is plaguing the country. When compared to United States' standards for air quality, about 3/8 of the population is breathing in air that is considered "unhealthy", which is reflected by the fact that about 1.6 million people die every year due to outdoor air pollution problems. The situation cannot continue if China intends to host the 2022 Olympic Games, where air quality can greatly affect an athlete's performance. The country has already taken measures, such as restricting the amount of vehicles driving, to combat the current conditions.

The project will study the air pollution problems and underlying factors that are contributing to the degrading air quality. Additionally, the project will study if the location of major systems (railroads, rivers, power plants etc.) has led to rapid industrialization and created highly polluted cities. By identifying factors and patterns, specific problem regions will be examined and possible remedies to reduce the effects of poor air quality will be proposed.

## Methodology

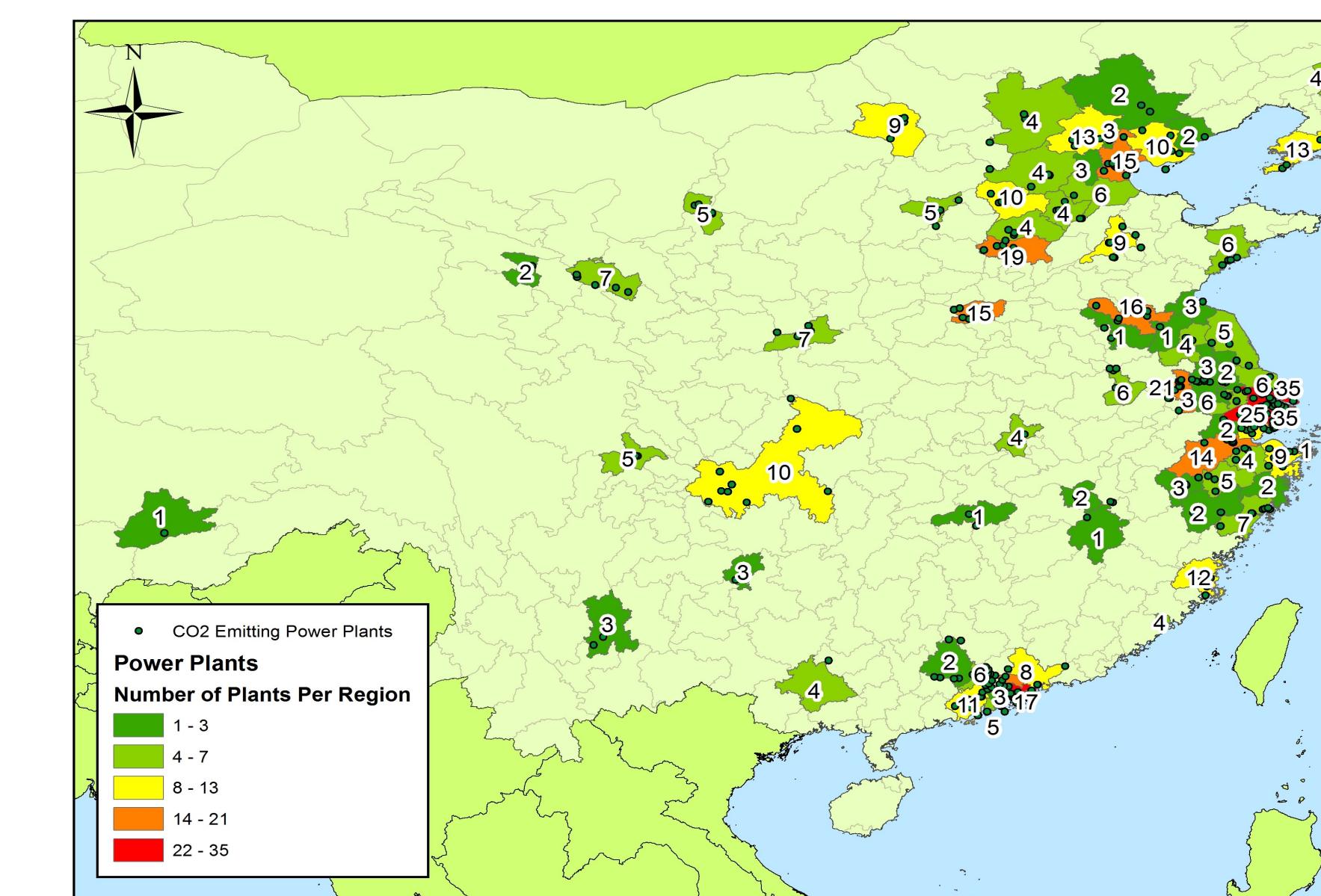
Particulate matter (PM) describes a mixture of liquid droplets and extremely small particles that are found in the air, such as soot, dust, etc. Particulate matter has been shown to have adverse effects on human health and cause problems like aggravated asthma or decreased lung functionality. These problems are caused by inhalation of particles into the lungs, and in some cases the blood stream. Therefore, regions with high particulate matter were identified as locations with poor air quality.

Particulate matter is released through various different mediums and can vary in size. PM2.5 describe particles with less than 2.5 micrometers in diameter and are classified as "fine particles". They are released through methods like automobiles, gases from power plants, or situations like forest fires. As a result, modes of transportation and carbon dioxide emissions from power plants were examined as factors leading to high particulate matter.

With different modes of transportation, the locations where they converge is important because those areas tend to be where many people travel for resources or attractions. For example, Boston is an area where many Massachusetts Bay Transportation Authority (MBTA) systems and highway roads meet because many stores and tourist attracts are located there. As a result, the regions of intersection is one indication of an industrializing area.

The intersections were examined along with their proximity to natural gas pipe lines. Natural gas is a clean-burning fuel that is very versatile, so it is an important resource that can be utilized for electricity, heating, and other industrial uses. As a result, the location of natural gas pipeline is important to the construction of industrialized areas because those areas would like to optimize their accessibility to the pipelines. One method to optimize

## Density of Carbon Dioxide Emitting Power Plants



their accessibility is to establish the urbanized area around the resources. Therefore, the location of natural gas pipelines and other resources could be an indication of industrializing areas.

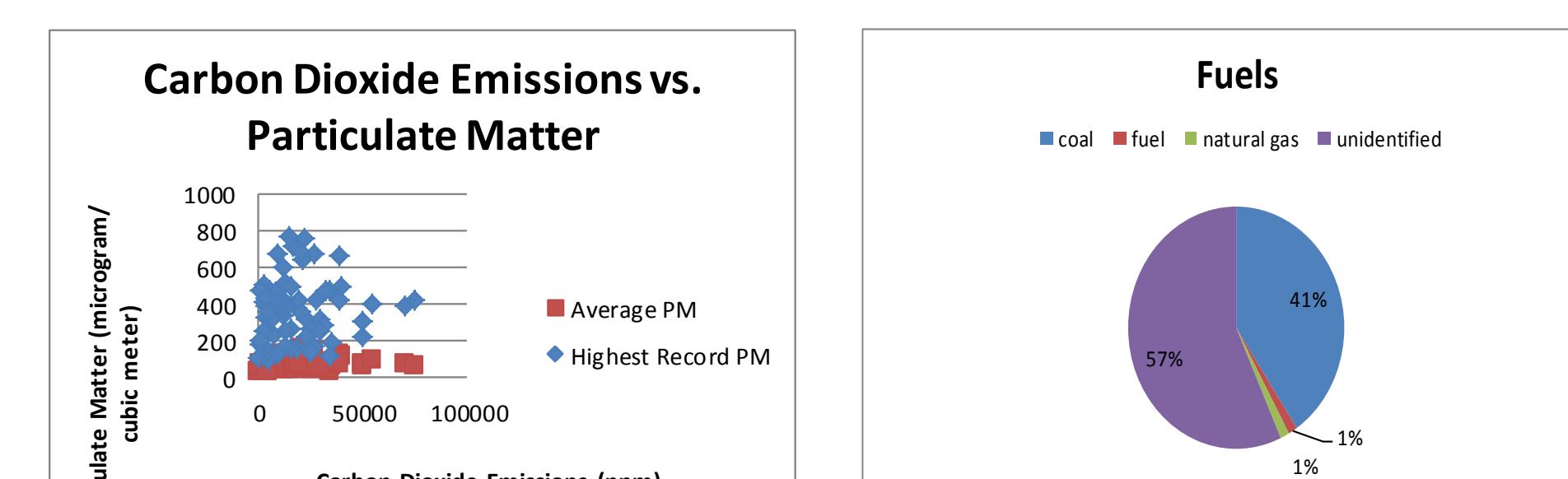
Lastly, the intersection data was viewed with gross domestic product (GDP) values for different regions. GDP represents the value of goods and services produced by a country. GDP can be measured through the amount of money earned in a year or the amount spent in a year. Therefore, GDP was used as an indication of an industrializing area on the basis that areas with high GDP have more money flowing through their economy, either through services they are providing or the business contained in that economy. The comparison situation is that locations with low GDP tend to be rural areas where many people are not located, so there is less businesses and less industrialization.

These three factors were used in conjunction with one another to indicate areas where high particulate matter could emerge from due to various methods.

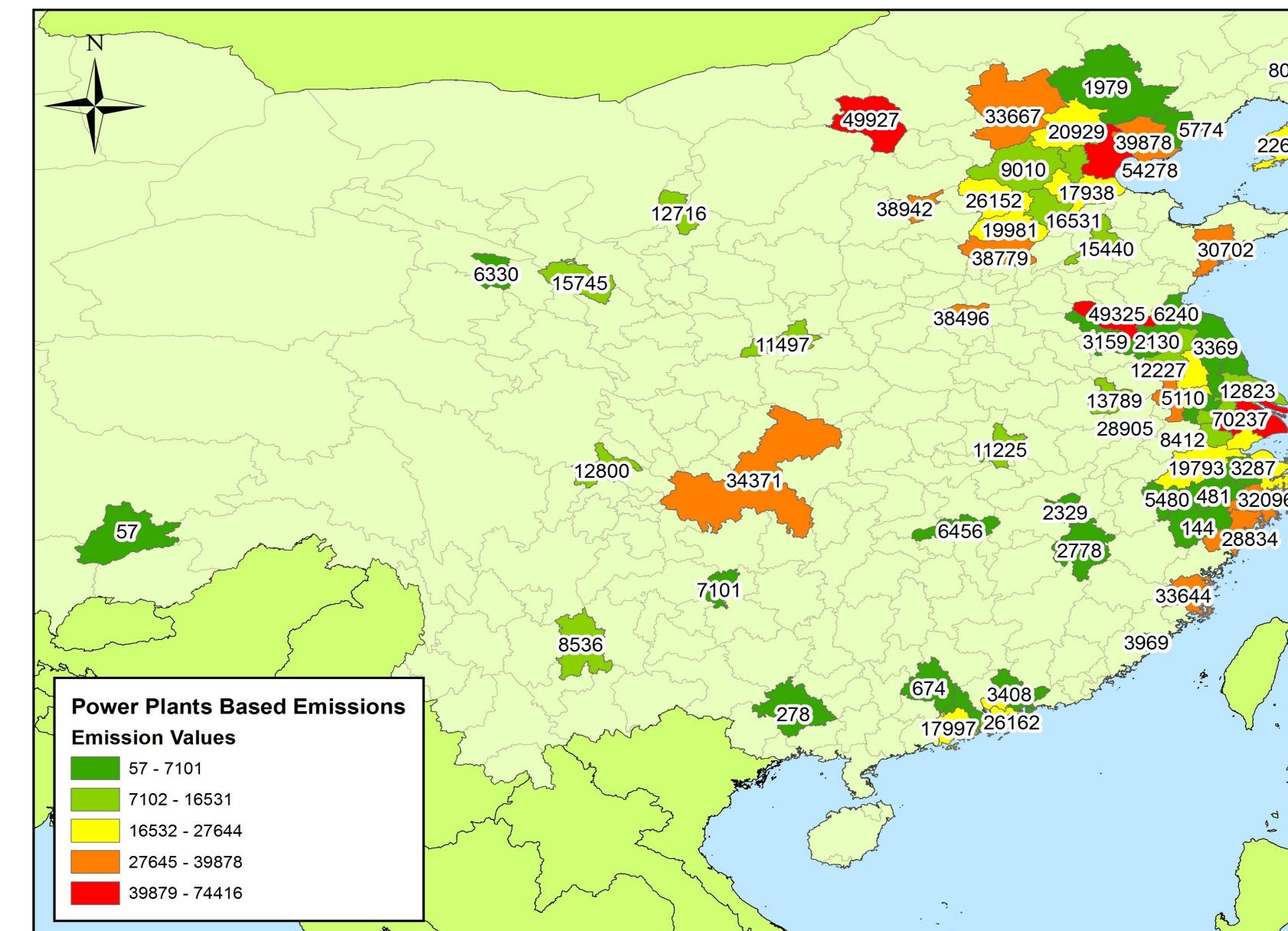
The next factor examined was the amount of carbon dioxide emitted through power plants from each region. When fossil fuels are combusted in power plants, carbon dioxide is emitted as a result. Therefore, the emission of carbon dioxide could be seen as an indicator of particulate matter on the basis that both are released through combustion processes. When more fossil fuels are burned, more carbon dioxide is released into the atmosphere and more particulate matters could be released as well. Inversely, when less fossil fuels are burned, there are less carbon dioxide emissions and less particulate matter is created. Therefore, the two would have a positive correlation with one another.

The carbon dioxide emissions were compared to the average amount of high particulate matter to provide a ratio. The ratio would be used as an indication to find anomalies within the data. If the relationship between carbon dioxide emissions and particulate matter is linear, then the ratio should be constant in all regions regardless of the amount of emissions. The ratio is used to determine irregularities in the data because regions with a high ratio means that there is less particulate matter in that region than is expected. Although a high ratio would be good for a region because there would not be a lot of particulate matter in the air, the implications are negative. A high ratio would indicate that the particulate matter are not staying in the air directly above the point of emission, but are being moved to a new location. As a result, the quality of air can be degraded in other regions.

## Results



## Carbon Dioxide Emission in High Particulate Matter Cities



One result shows how a significant number of intersections between trains and highway roads coincide with the location of natural gas pipe lines. Additionally, those locations are along regions with high GDP values. The map demonstrates how the location of modes of transportation intersecting and natural resources may lead to increased industrialization, seen through the GDP values. These factors could be an underlying cause for the location of high particulate regions.

A second result from the scatter plot shows no real relationship between the carbon dioxide emission levels and particulate matter, although a positive correlation is expected. Therefore, there is another factor that is not being account for that is altering the data. One possibility that Berkeley Earth suggests is that wind is moving the high particulate matter into other regions, and as a result, increasing the ratio value. Regions with high emissions and relatively low particulate values, such as Chongqing (one of four municipalities), are an irregularities in the data, meaning that the high particulates are being moved to other regions. Another irregularity is Baoding and Beijing. The Baoding has more particulate matter measured than Beijing, although Beijing has more than double the emissions. There is a possibility that particulate matter from Shijiazhuang is being blown into Baoding to increase the readings and lower the air quality.

## Conclusions

The explorative study has shown that many regions are prime locations for industrialization due to ideal circumstances, such as accessibility to natural resources or different modes of transportation. Although many other conditions contribute to the increase in particulate matter in the air and the decrease in air quality, the ones mentioned in the study are preliminary findings meant to show correlations between different factors.

Additionally, the irregularities in the data indicate that the movement of high particulate to other regions of China is possibility being caused by wind. Although the air quality many improve in some regions, it will degrade in others. The variability in the wind speed and particulate matter size could cause difficulty when trying to identify the source regions that are cause larger problems.

Identifying causes for air pollution is difficult due to the number of important factors that can contribute to the problem, but it is a critical task in order to determine methods to improve our environmental contribution.

## Limitations and Future Improvements

One limitation to the study was the availability of data related to China that could be used to determine vital information. Although there are sources of data, they are very limited; even with the data found, finding the correct file format for ArcGIS was difficult. Another limitation was the documentation of the obtained data contained information in other languages, so they could not be fully utilized.

For future improvements to the study, I would like to obtain carbon dioxide emissions from other sectors and wind directional data to determine the conclusion was accurate. Additionally, I would like to find a more direct correlation between carbon dioxide emissions and particular matter readings to better understand the ratio created.

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Date: 15 December 2015  
Course: CEE-187: Introduction to GIS  
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## Comparing Carbon Dioxide Emission to High Particulate Matter Cities

