Introduction:

Geographic Information Systems (GIS) have been widely used in the field of transportation since location information is critical for transportation applications such as transportation planning, modeling, accident analysis, transit service planning, etc. The significant contribution that GIS offers is the ability to manage data spatially and then overlay these layers to perform spatial analyses. Thus a transit routes layer and an individual bus stop layer when overlaid on a land use layer we can analyze the socio economic characteristics of the area surrounding transit route and bus stops by buffering that area. GIS also provides the ability to calculate the shortest path to any particular bus stop from any particular location. These capabilities enable transit agencies to geo reference their bus routes, time points and other features to a digital street centerline.

This paper focuses on how GIS can be used in mass transit planning to understand and analyze basic ridership characteristics. Mass transit is gaining a lot importance these days because of the growing concern over the impact of cars on the environment and the quality of life in urban areas. This paper used GIS to investigate the ridership characteristics of the transit system in Greater London and the D.C. Metropolitan region.

Review of example applications:

View2Transit: An Arc View 2 Application for Transit Planning and Marketing:

View2 Transit is an Arc View 2 application developed by the San Diego Association of Governments (SANDAG) for use by non-GIS transit professionals. . It is an effort by SANDAG and the transit operators to design a GIS that answers a variety of transit-related questions inexpensively and with minimal assistance.

The application puts a variety of spatial databases directly in the hands of transit planners, marketers, and other decision makers. View2Transit databases include historical, current estimates, and forecasts of population, housing, and employment, transit rider ship, transit stop characteristics and route alignment. Most of these data are stored for geographic areas smaller than a census block, which makes buffering or capturing data to user-defined areas more accurate. The transit professional gains freedom and flexibility in problem solving through View2Transit's geographically detailed databases and direct access to mapping and analysis tools. Because the application is customized using Avenue scripts, the user does not need in-depth knowledge of Arc View 2. View 2 Transit is used by operators in the San Diego region as a tool for more effective planning and marketing of transit services.

The objectives of this project are:

V2T gives **direct access** to commonly used information; as a result operators are able to integrate information that is collected.

Geographic Analysis: V2T allows for analysis of data at various geographic scales, with the base geographic area smaller than a census block. Buffering and aggregating to virtually any size study area are more accurate, from the immediate area surrounding a transit stop or route to entire service areas.

Data Integration: V2T provides the operators with the capability to integrate data from a variety of sources. A common request from operators is to provide socio-economic data for areas surrounding a busy transit route. This type of integration is a central feature in the application.

Ease of Use: The most important objective of V2T is that it is a GIS for non-GIS users. Transit operators are able to use this application with minimal training time and expense.

At the start of the project, a development committee was put together with staff from SANDAG and the transit operators. This committee designed the elements of the project, formulated responsibilities and time schedules, and discussed relevant applications. The group compiled a list of these applications to be included in V2T and reached consensus on a base set of applications including:

- Analyzing the socio-economic characteristics of areas surrounding transit routes and individual stops.
- Analyzing transit rider ship by stop by time of day.
- Analyzing the physical characteristics of transit stops.
- Analyzing future growth areas for transit.

Technology is emerging which puts more effective tools directly into the hands of transit planning and marketing staff, and this is the case with desktop GIS applications. The transit operator can now do projects that have previously been done in-house by SANDAG GIS staff, with tools provided by SANDAG staff. The benefits to the transit operator include more immediate answers, the ability to ask related questions more easily, and new applications (e.g. incorporating in-house data).

One of the objectives of V2T is to provide GIS to non-GIS users, including preprogrammed functionality. While in-depth knowledge of Arc View 2 is not necessary, the more familiar the transit analyst is with the software, the more results are possible especially in other areas not specifically related to the two applications in V2T. These include incorporating data not maintained at SANDAG and functions such as address matching. Using V2T to obtain more knowledge of Arc View 2 will be of great value.

To date, V2T is in the beta testing stage. Two transit operators are acting as beta sites and evaluating the overall project, performance, databases, buttons, and user's documentation. This study illustrates the level of cooperation and the effective working relationship, which exists between SANDAG and the transit operators providing service in the San Diego region. Questions such as analyzing the alternatives to a new trolley line, to identifying the potential riders of a bus route extension, to analyzing boarding's by time of day can now be answered more easily. Planning and marketing efforts to enhance the current level of transit service and increase rider ship are benefiting from View2Transit.

***Milwaukee Downtown Transit Connector Study*:**

In 1999 the Wisconsin Center District completed construction of the new Midwest Express Center, downtown Milwaukee's convention and meeting center. The initial GIS task was the preparation of a base map for the project area from the original street base that was obtained from the City of Milwaukee. This mapping included street rights-of-way, building footprints, and parcel delineation from Micro Station files. The parcel mapping became the first layer for the project database by converting the Micro Station files to ArcView shape files.

The use of GIS technology was selected to provide the project with the most cost-effective as well as technologically advanced means by which to develop and analyze alternatives. A GIS system has the ability to tie specific data to map features. This allows the use of both visual information on a base map and statistical information from a database, such as data from a specific parcel or census tract. In this case, the data collected was tied to specific parcels and later aggregated to larger geographic units such as blocks, key locations, and combinations of potential routes through spatial analysis.

Several layers of information were placed upon the original street and parcel base. The project team joined land use and property data with a parcel map using the tax IDs. From the base data the team developed new and expanded upon the existing data to meet the study goals. GIS allowed the team to review information for each parcel and use that information in determining where alignments should be located and where stations or stops could be most effective in serving the downtown.

More detailed information was necessary in the core downtown area because a large number of the buildings in the downtown core were located on several parcels. Hence a building data layer and a database were developed to associate the detailed information for the core downtown area. Data was verified data through field checks, entered the data into a database and then joined the database with the polygon of the building footprint.

The resulting database is a compilation of land uses, zoning and economic data on individual properties combined with specific information on buildings in the downtown core. Information has been compiled on the number of residential units, an estimate of office employment, the number of public off-street parking spaces, number of hotel rooms, and the number of visitors expected annually to the various attractions and tourism/convention venues.

Utilizing the GIS, the land use base data was analyzed both with data queries and spatial analyses. In order to compare future alternatives, a base data table for the study area was prepared. This base data table consists of the existing land use and the key elements to analyze both build alignments and station locations.

One of the first planning and GIS tasks undertaken as part of the Milwaukee Connector study was the determination of those sites and areas, which should be "connected" by any new transit service in the downtown. A quick look at the study area indicates there are many potential destinations in the project area. Any system ultimately constructed would be limited in the area it could serve and the number of places it could stop. One of the key decisions that needed to be made is which of those destinations will be directly served by the proposed system and which will not.

Station Location Analysis – Throughout the study over 60 station locations were identified for the station location analysis. Each station location was buffered by both the 1/8-mile and ½-mile distance and overlayed (clipped) to the land use and associated attributes layer. Tabular summaries of results were developed for each station. Through the review of the results the study team was then able to adjust the location, if needed, to assure that it met the criteria at the highest potential for the location. Locations in the downtown were dependent on meeting criteria for employees and entertainment. The surrounding neighborhoods were located with residential considerations as the main criteria.

Station Location By Route Analysis – The route analysis consisted of identifying the station locations for each route and buffering the stations by both walking distances. A number of routes contained variations along the route to analyze the most potential according to the above criteria for the route. For instance: A route running along Wisconsin Ave. may split at a point to analyze if there would be more "hits" with the criteria on Wells St. versus Wisconsin Ave. This type of variation added to the number of routes with varying stations to be buffered and overlayed to the land use and associated attributes layer. Once the variations were calculated, the data was used for other routes. However, the station overlay to land use by route was very extensive and would not have been feasible without the use of GIS. The data extracted from this process was summarized for review by the team. As the team assessed the routes and variation of those routes, other routes became apparent and the process was repeated until the ultimate routes were chosen.

Station Location By Build Alignment – Combination of the routes make up the build alternatives. GIS provided the ability to mix and match the ultimate alternative build alignments for the transit system. As build alignments were developed they were also buffered and overlayed to the land use to assess the potential of the entire connector system

Ridership Analysis

GIS was utilized to assess the existing and potential ridership for the connector system. It was realized that the information projected from other studies were substantially lower than the data associated with the 2020 scenario developed with the GIS. Ridership is developed through a modeling program using existing or projected land uses, population, retail and office employment, and other generators. The data contained within the studies land use was used to adjust the 2020 scenario for ridership. By overlaying the Traffic Analysis Zones (TAZ), used in the modeling, with the land use, 2020 ridership figures were developed.

It is thus very clear that GIS is a very useful tool for mass transit. It is flexible to the extent that it can be customized to suit the requirements of a team. For Example View2transit (V2T). This application software was developed from Arc View to provide GIS to non-GIS users. A GIS system has the ability to tie specific data to map features. This allows the use of both visual information on a base map and statistical information from a database, such as data from a specific parcel or census tract. In this way the data collected can be tied to specific parcels and aggregated to larger geographic units such as blocks, key locations, and combinations of potential routes through spatial analysis.

In this paper too the riderhip characteristics of D.C. Metropolitan region and Greater London were analyzed through spatial analysis. In this paper, riderhsip characteristics essentially refer to the mode of transportation of the working population and their socio-economic characteristics. The riderhsip characteristics help us understand generalized travel patterns and the preferred mode of transportation; whether the people prefer public transportation to private transportation. My analysis supported the concept that there is often a nexus between the choice in the mode of transportation, and the socioeconomic conditions of the working population.

Both Greater London and the D.C. Metropolitan region have a well-developed Public transit system. Yet research has proved that the London Transportation system is more successful than most American public transportation systems. London Underground was the world' s first underground railway system and revolutionized urban transport across the globe. It would be interesting to examine and analyze the travel patterns in these two regions.

The DC Transit System:

The Washington DC metro system was opened in 1976 . The metropolitan area includes northern Virginia (Fairfax County, Arlington County and City of Alexandria), Maryland (Prince Georges County and Montgomery county) and DC. The Washington Metropolitan Area Transit Authority (WMATA) is responsible for construction and operation of the 103-mile Metro rail system in the District of Columbia, Northern Virginia, and Maryland. It also manages a regional bus system. WMATA is the second largest bus/transit system in the nation.

The rail system carries 600,000 passengers on an average weekday. It consists of four lines, designed to follow existing or planned higher-density development corridors in the various jurisdictions. Many lines are routes along major road and highway corridors, although some follow railroad rights-of- way for all or part of their length. Stations were located at existing and future activity nodes. Much of the system in the District and close-in jurisdictions is underground.

Planning for TOD in the Washington metropolitan area has been somewhat uneven given the unique political setting with two states and the District of Columbia. The district, for example, has provided little leadership or TOD planning for the areas surrounding the 34 Metro rail stations within the District of Columbia.

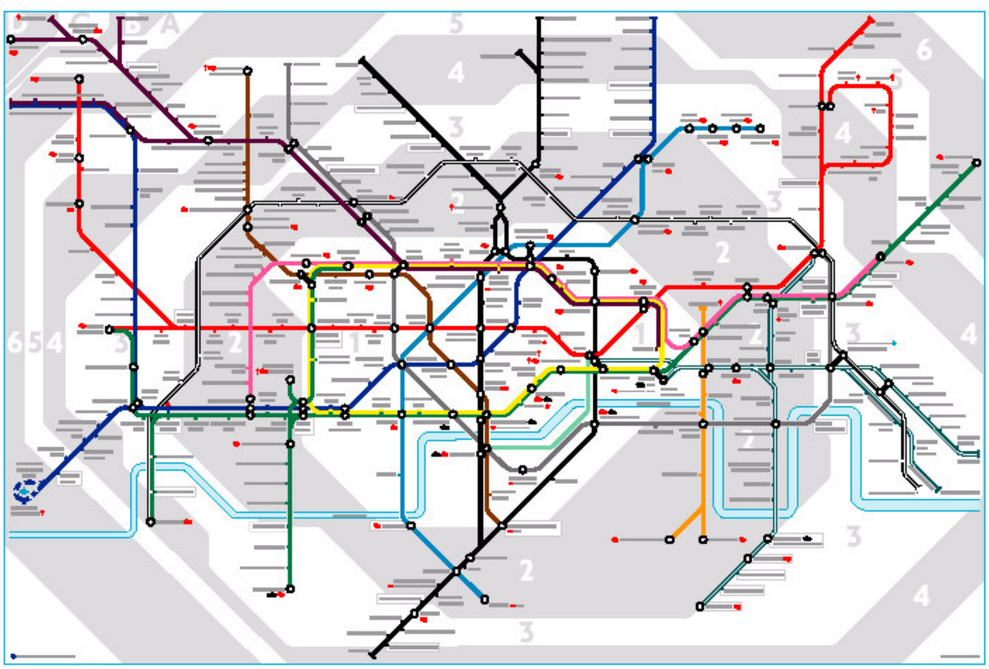
Figure: 1 **D.C. Metro System**

London Transit System: It comprised the LTC (London Transit Commission) buses, London Underground i.e. the tube and train services. The LTC buses system is spread throughout Central London, inner London and outer London. It brings around36, 000 passengers everyday to the heart of the city.

London Underground was the world's first underground railway and was formed in1985, but its history dates back to 1863 when the world' s first underground railway opened in London. It revolutionized urban transport across the globe. Hence historically London underground may be considered as a premier mass transit system in the world. The electrified railway system runs underground in central London and above ground in London suburbs.

Today, London Underground is a major business with three million passenger journeys made a day, serving 275 stations over 408 km (253 miles) of railway. In 2002-2003, London Underground drove a total of 65.4 million kilometers. Since 2003 the Tube has been part of transport of london (TfL), which also schedules and lets contracts for the famous red double-decker buses (tourist buses).Previously London transport was the holding company of London underground. A lack of lines in the south of city is because of the geology of that area, that region being one large aquifer.It is difficult to construct the lines on such type of topography.This is made up by a number of suburban rail services made by south west trains , south central and south east trains.

Figure: 2 **London Tube Map**



Data Collection:

Methodology:

Tiger data was downloaded for the counties directly affected by METRO. These include; Washington D.C., Fairfax County-VA, Arlington County –VA, Alexandria City-Virginia, Falls Church City –VA, Montgomery County, MD and the Prince Georges County, MD, (Please refer to map 1A).All of the above themes were merged into a single shapefile in Arc GIS. Data for transportation was downloaded from the census website for each county. The data from the census website of all the counties in the DC Metropolitan Region was formatted in tabular format and joined to the table of the counties shape file.

U.K. census and London Underground provided the data for analysis of Greater London. (Greater London, refer to Map 1B)Data for Local Authority Districts were available in shape file format from UK census London underground provided the data in shape file format for underground network. The data for Local Authority District of Greater London was downloaded from the UK census website. The data was then formatted in tabular format and joined to the table of Local Authority Districts Shapefile.

There were some constraints experienced while gathering Greater London transportation data on bus routes and train lines due to which shape files for the bus route were not available as in the case of DC metro. However a map of Greater London bus routes was used for the analysis.

The Spatial distribution of population representing the demand for different transportation mode for grater London and DC was analyzed using Raster method. Population characteristics in terms of race, Socio-economic status and Vehicle ownership was also analyzed using the raster method. However in case of D.C. the spatial distribution of the population traveling to work by bus was analyzed using both raster and vector method in order to show the difference between the two methods.

Within raster analysis the “Inverse Distance Weighting” method was used for analysis. “IDW estimates cell values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process. This method assumes that the variable being mapped decreases in influence with distance from its sampled location”(*Source, ArcGis Help)*.

The Z variable calculated for this method was mostly percentages representing spatial distribution of rider ship demand for Bus, Metro, Cars, and Carpooling. However for determining the socio economic status for the DC population the Z variable was Mean Income .In case of London the data representing the socio economic status was available in different class groups with each group representing a particular type of work.

The Z variable was calculated in percentages for each class of workers and the spatial distribution for every category was separately analyzed. “Race” for both DC and Greater London was calculated in percentages. Calculations represented values at block group level for DC and output area level for Greater London.

This paper attempts to analyze the rider ship characteristics of the working population of the DC metropolitan region and Greater London with respect to the following modes of transportation. Arc view 3.3 was used for analyses.

1. Bus: Studies the spatial distribution of the population using bus as the mode of transportation to work.
2. The metro: Studies the spatial distribution of the population using only metro as the mode of transportation to work.
3. The spatial distribution of the population who carpool to work/ or Drive alone
4. The Socio economic characteristics of the population.

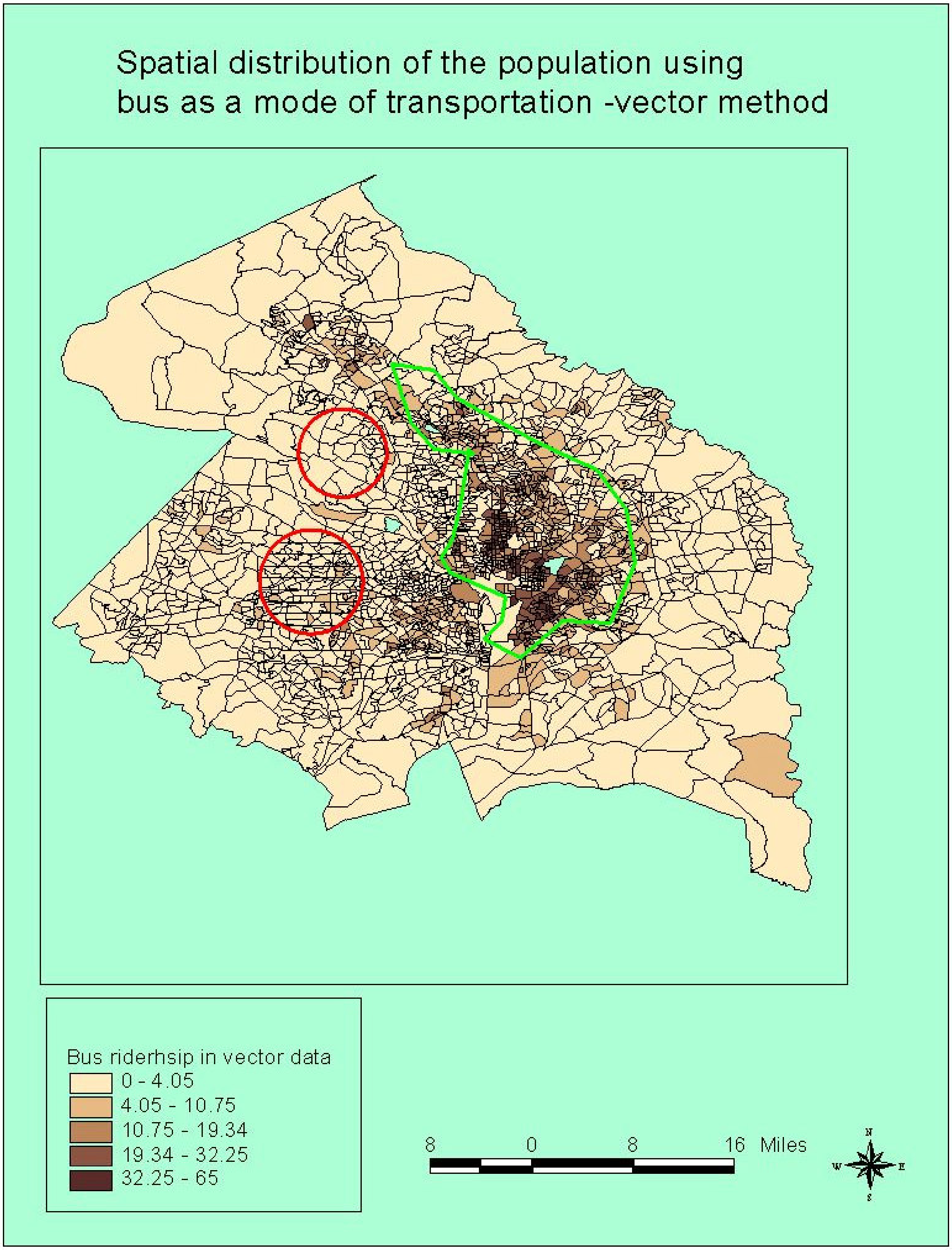
Analyses and Findings:

1. Bus as a Mode of transportation:

Dc Metropolitan Region:

The overall picture shows a higher percentage of riders in the eastern part of D.C. (Refer to map 2A pg. No.13). 60% of the population prefers to commute by bus. The red circles on this map are those areas where the ridership is low even though there is a dense network of bus routes. The western part of DC near Falls Church and Fairfax city we find a dense network of bus routes but not high density of rider's .The rider ship being mainly between 4-10%. A zoomed up area of that portion is show below this map on page 14 and 15.

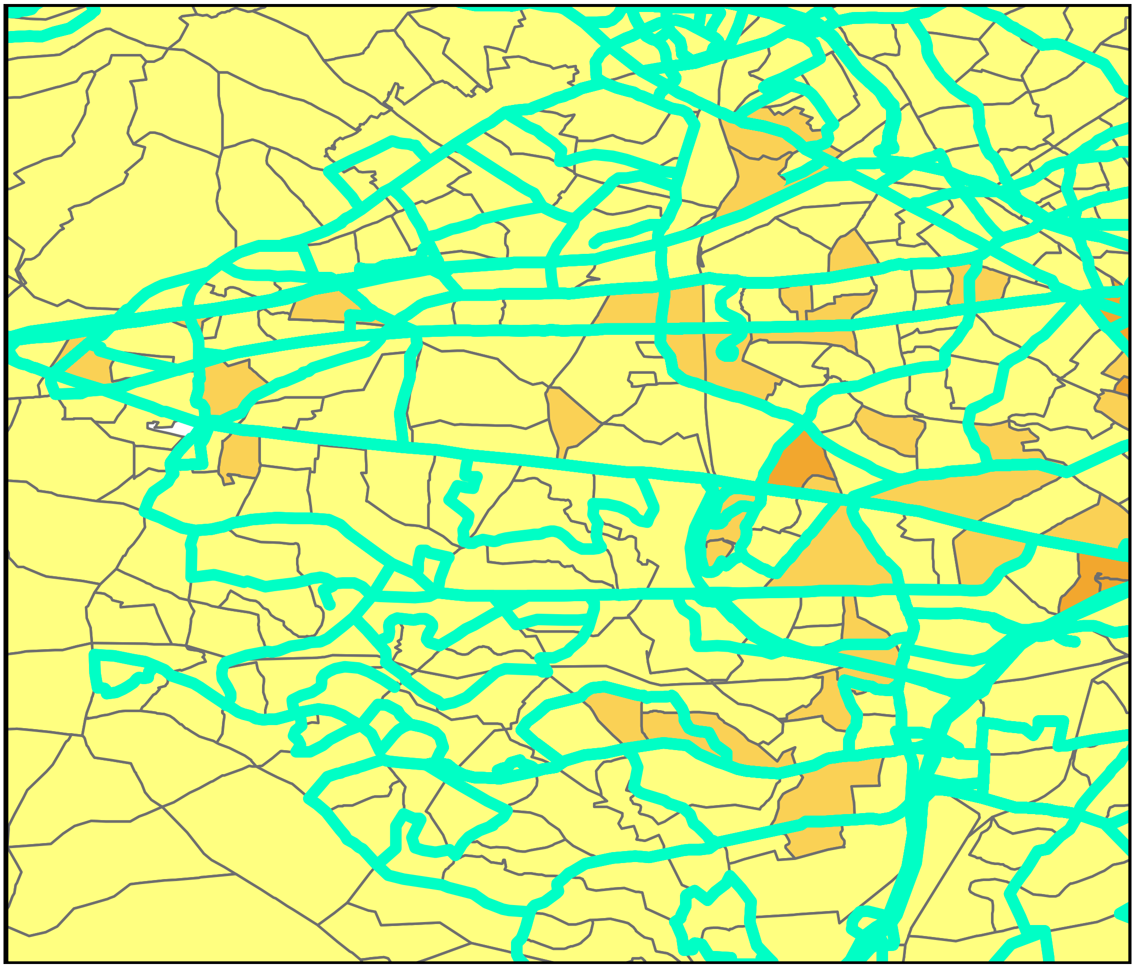
MAP 2A



Spatial distribution of the population using
bus as a mode of transportation -vector method
Bus riderhsip in vector data
0 - 4.05
4.05 - 10.75
10.75 - 19.34
19.34 - 32.25
32.25 - 65
8
0
8
16
Miles

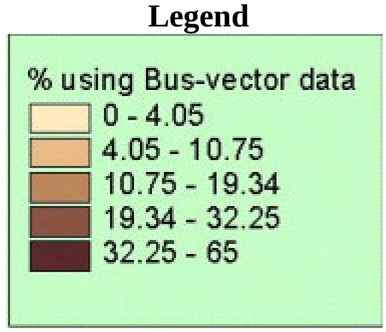
Bus Routes in Fairfax County / Falls Church where riderhip is low

MAP 2A(i)



The blue lines represent bus routes.

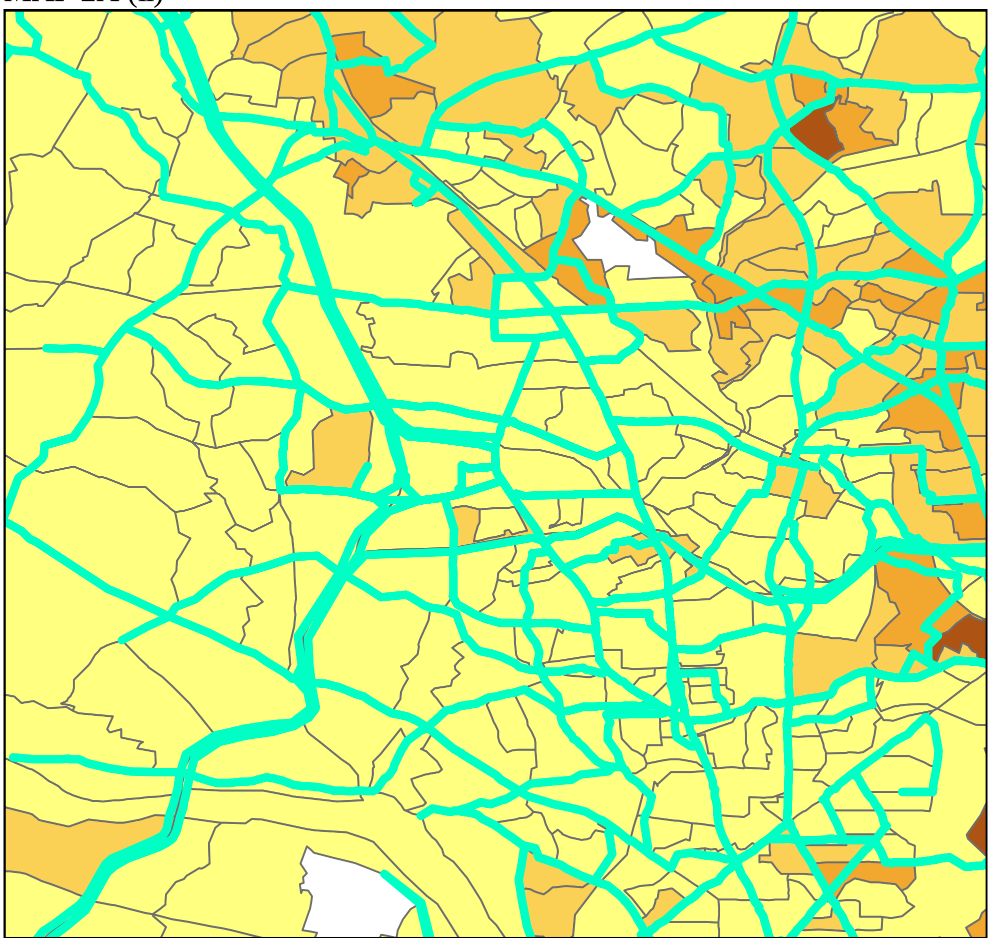
Legend

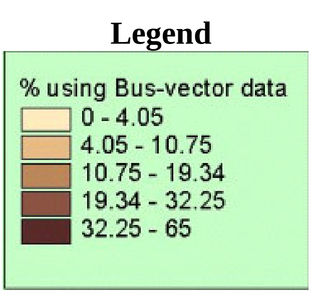


Again a small pocket in the Northwestern part of D.C., which is a part of the Montgomery County shows dense network of bus routes but not as high a demand.
A zoomed up portion of that area of the map is shown below.

Bus Routes in Montgomery County where ridership is low

MAP 2A (ii)

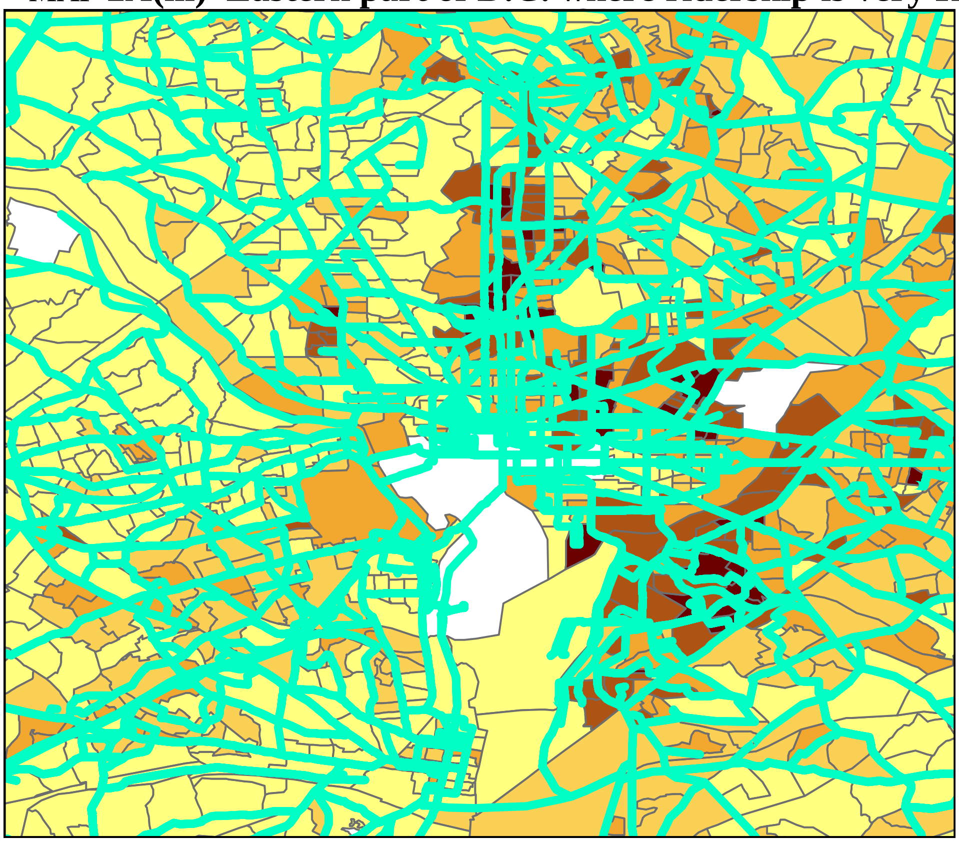




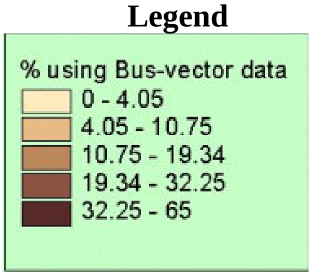
Both Montgomery County and Fairfax County are known for their high standard of living and good school districts. Hence population up here may prefer private transportation to public transportation. This factor could be attributed for the low ridership. Another explanation is that this area might be the destination point for those coming from other areas using bus as their mode of transportation.

Fairfax county, Montgomery county and DC are known for the wide variety of job opportunities as well as the Hi-tech firms. Thus the need to serve these areas by a strong transportation network is very important.

MAP **2A(iii) Eastern part of D.C. where ridership is very High**



Legend

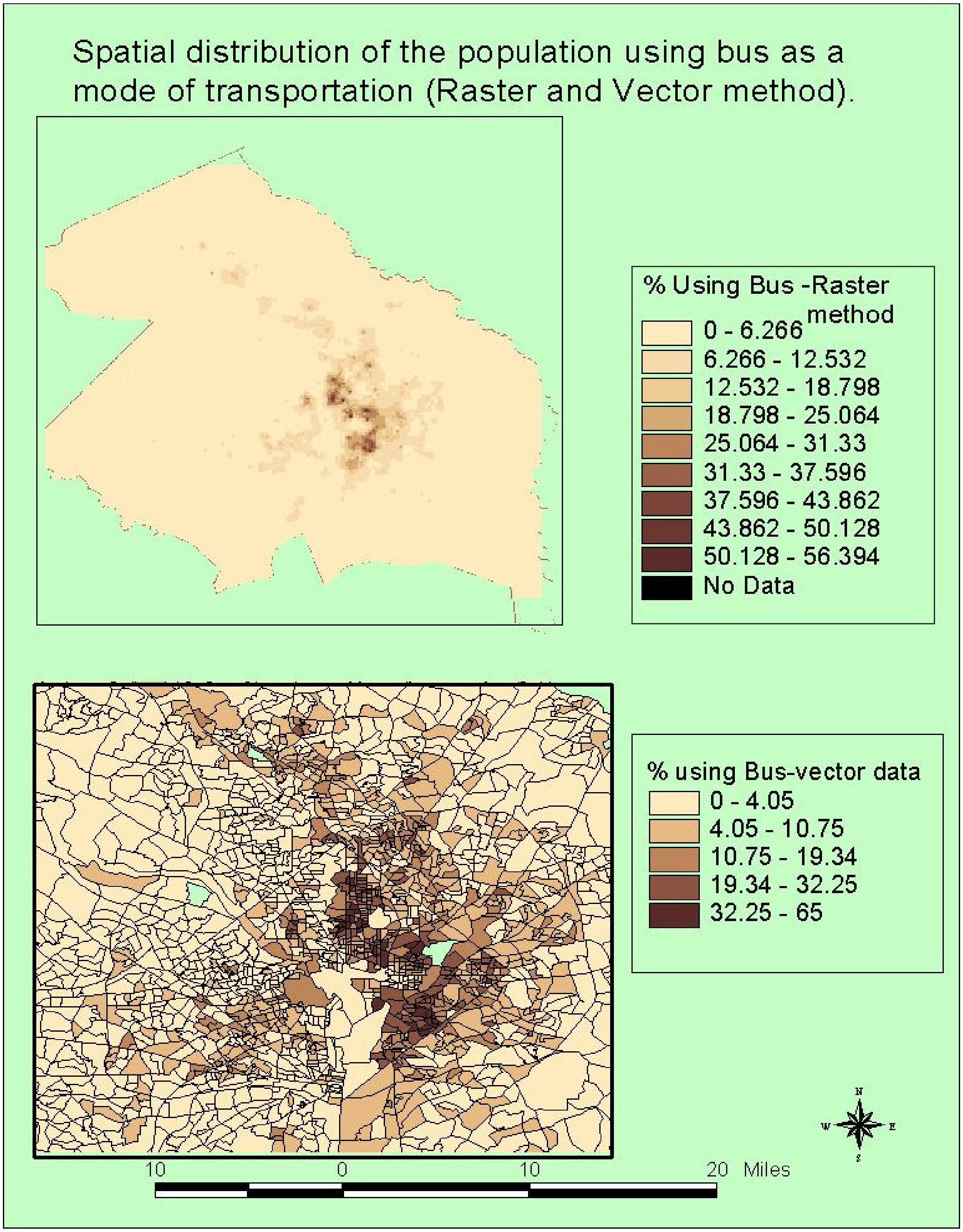


Again rider ship is highest in the eastern part of DC ranging between 30% to 65%.A zoomed up portion of that part of the map is shown above on page 17.

Now the same analysis was done using the *raster method*.

The following map 2Aac (pg.18) shows the visual difference between the two methods. Vector data models are composed of points and they are not very good structures to use if the map to be generated involves filling areas with shades or color. Rasters are detailed, highly structured, easy to understand and capable of rapid retrieval and analysis.

MAP 2Ac


Spatial distribution of the population using bus as a mode of transportation (Raster and Vector method).
% Using Bus -Raster method
0 - 6.266
6.266 - 12.532
12.532 - 18.798
18.798 - 25.064
25.064 - 31.33
31.33 - 37.596
37.596 - 43.862
43.862 - 50.128
50.128 - 56.394
No Data
% using Bus-vector data
0 - 4.05
4.05 - 10.75
10.75 - 19.34
19.34 - 32.25
32.25 - 65
10
0
10
20 Miles

***London*:**

Buses serve a vital segment of the travel market in London. Statistics show that in London there are more bus journeys than underground journeys(refer to map 2B pg.21).70% of the bus journeys are less than three kilometers long.55% of bus trips wholly within outer London and 40% within inner and central London. That segment of the population who do not have access to car like women, children or pensioners or the old people, who have free travel permit mainly use bus services.

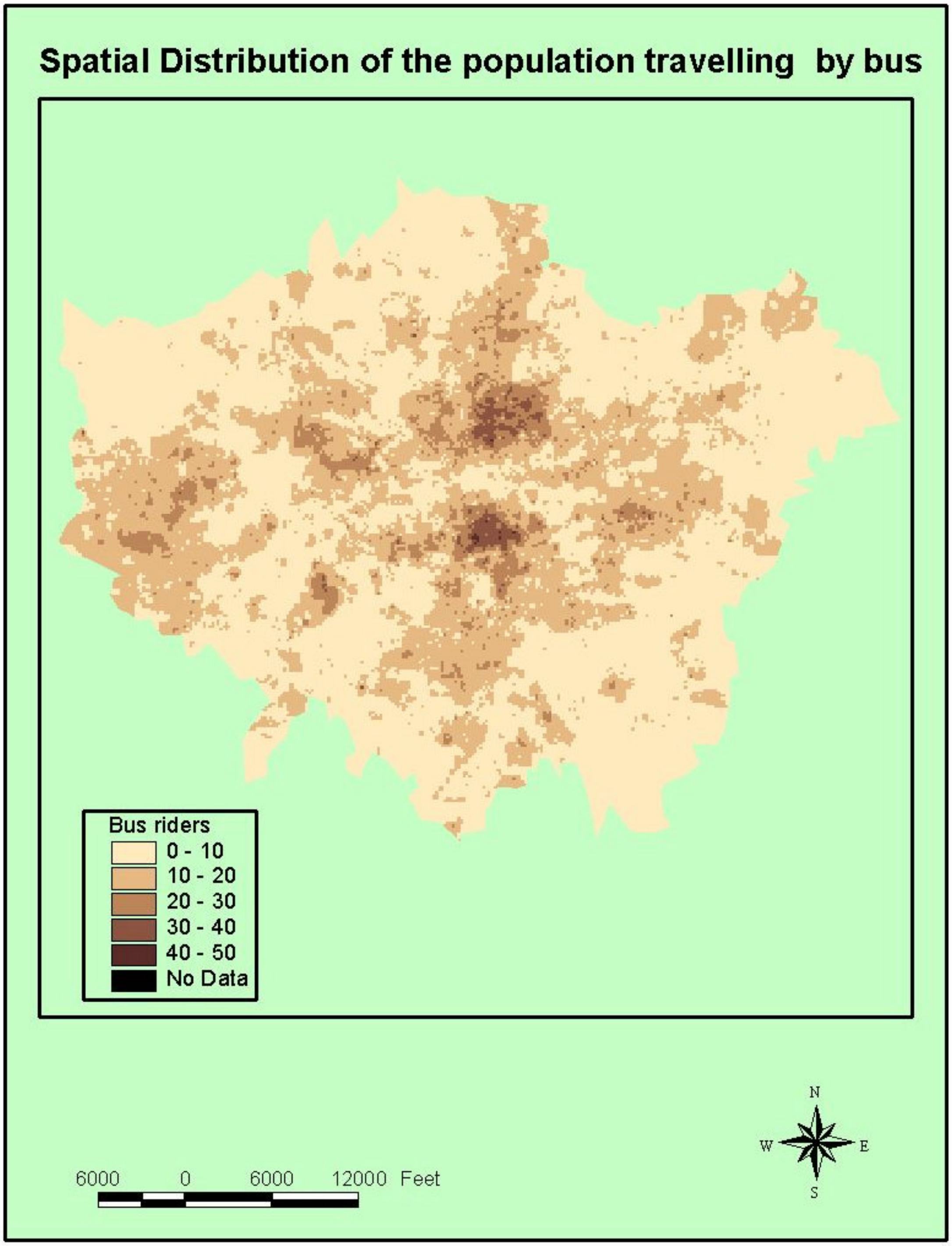
The present analysis did not have the bus routes in shape file format, however a picture of the same has been used to explain the analyses. The map below shows the bus network in greater London.

Figure: 3 **Bus Routes in London**

The green lines are the bus routes under construction. Hence they have not been considered for the analysis. The Dark gray area in the center represents Central London, light gray around it is inner London and beyond that is outer London.

It shows Inner London and beyond that shows Outer London. If we overlay the bus routes map on the bus ridership map we do see that demand is high in central and inner London and is less in outer London.

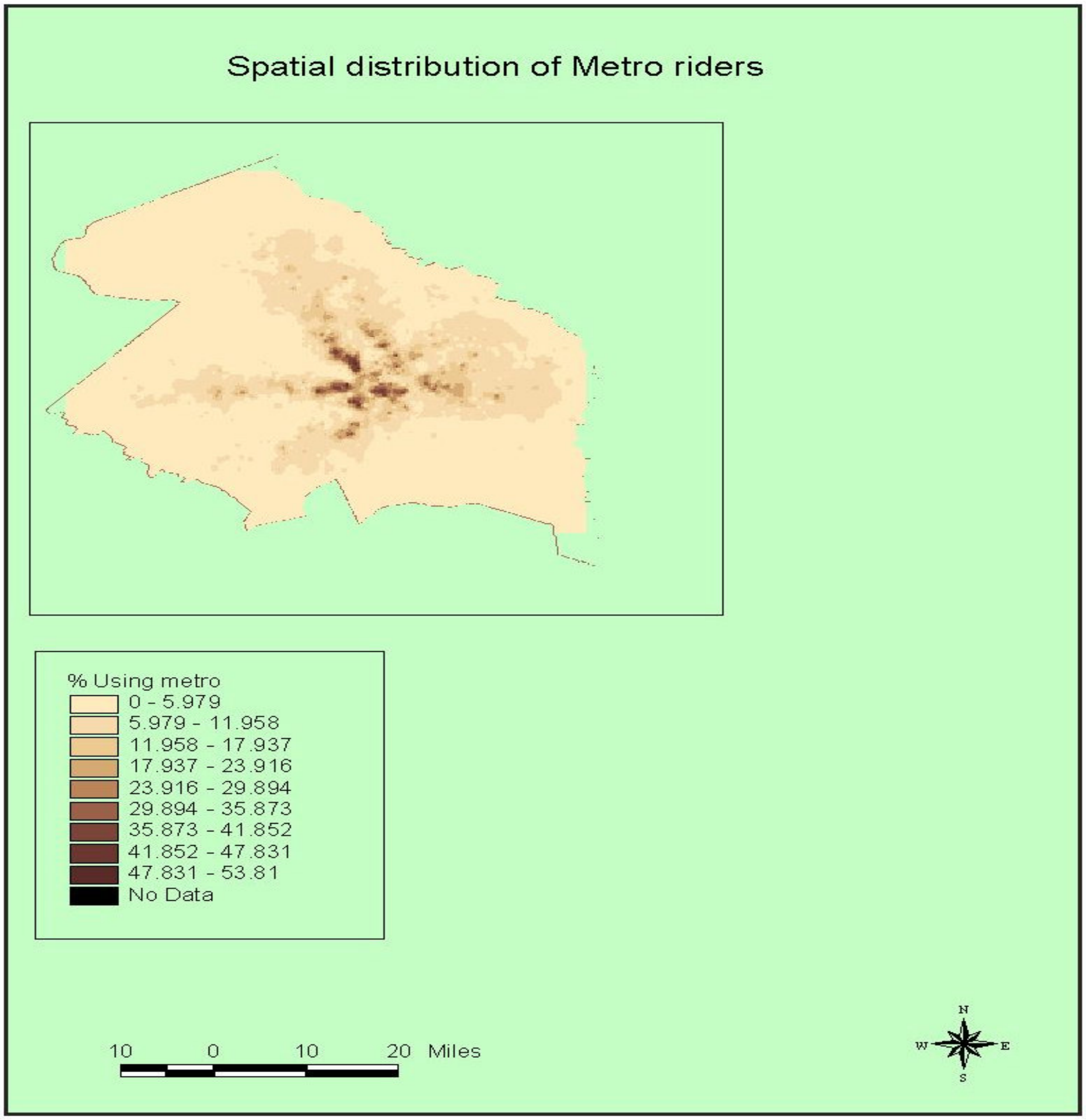
MAP 2B


Spatial Distribution of the population travelling by bus
Bus riders
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
No Data
6000 0 6000 12000 Feet
N
W
E
S

2. *D.C. Metro:*

The density pattern of rider ship for subways or metro showed that ridership was high along the metro stops. And there was a decrease in riderhip away from the metro stations. More than 50 % of the population living near the metro stops used metro as a mode of transportation. (Refer to map 3A, pg.17)

MAP 3A



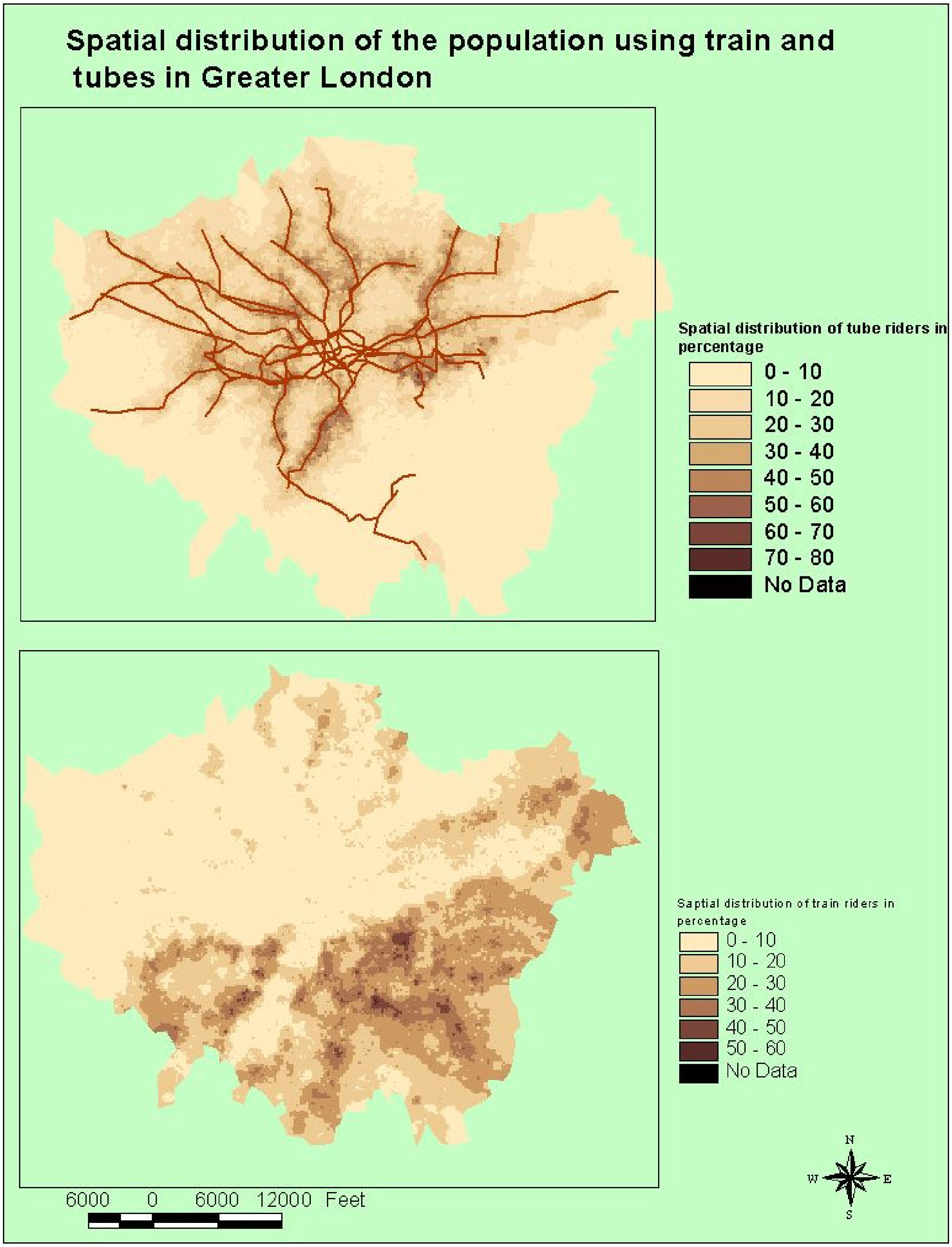
London underground:

Travel pattern here is the same as in DC. Riderhip being highest along the tube lines. But right in central London very few use the tube for commuting, though a dense network of trains and tube lines operate in central London. Demand here is just 10 % compared to the 80% demand along the tube lines. Central London being the hub of all business activities this area should have shown a high ridership for tube.

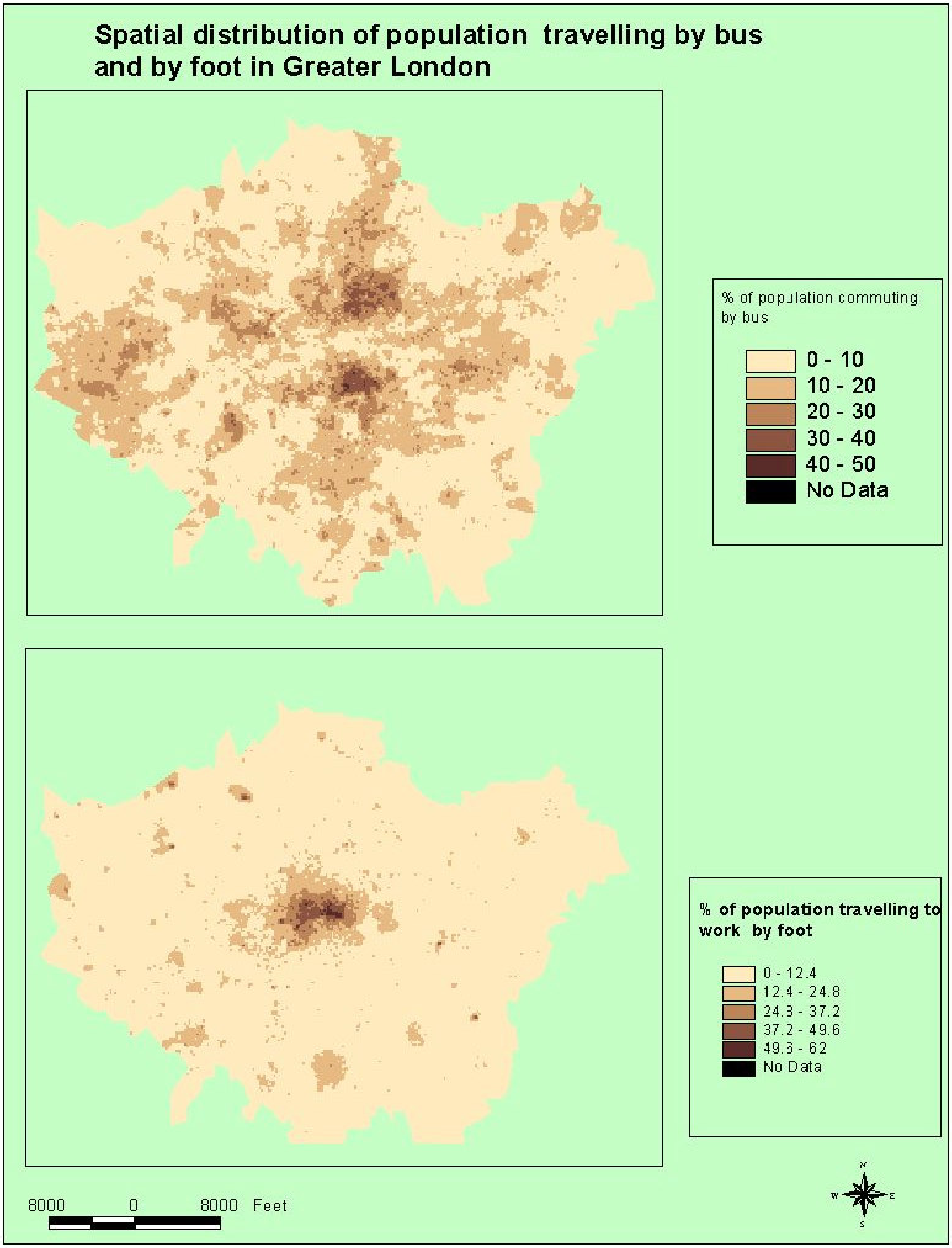
Hence the analysis for other modes which were not done before like using bicycle, moped, taxi, foot were also done to see which mode showed highest demand in central London. It was found that travel to work by foot was the most preferred mode in central London. Which means people living in Central London mainly walk to their place of work. (Refer to map 3B and 3B(i) pg 24).

The southern part of Greater London has very few tube lines due to the geology of the soil up here. However the train lines that run from here to central London compensate this. Therefore in map 3B we find more train riders in the southern part of Greater London.

MAP 3B


Spatial distribution of the population using train and tubes in Greater London
Spatial distribution of tube riders in percentage
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
No Data
Saptial distribution of train riders in percentage
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
No Data
N
W
E
S
6000 0 6000 12000 Feet

Map 3B(i)


Spatial distribution of population travelling by bus
and by foot in Greater London
% of population commuting by bus
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
No Data
% of population travelling to work by foot
0 - 12.4
12.4 - 24.8
24.8 - 37.2
37.2 - 49.6
49.6 - 62
No Data
8000
0
8000
Feet

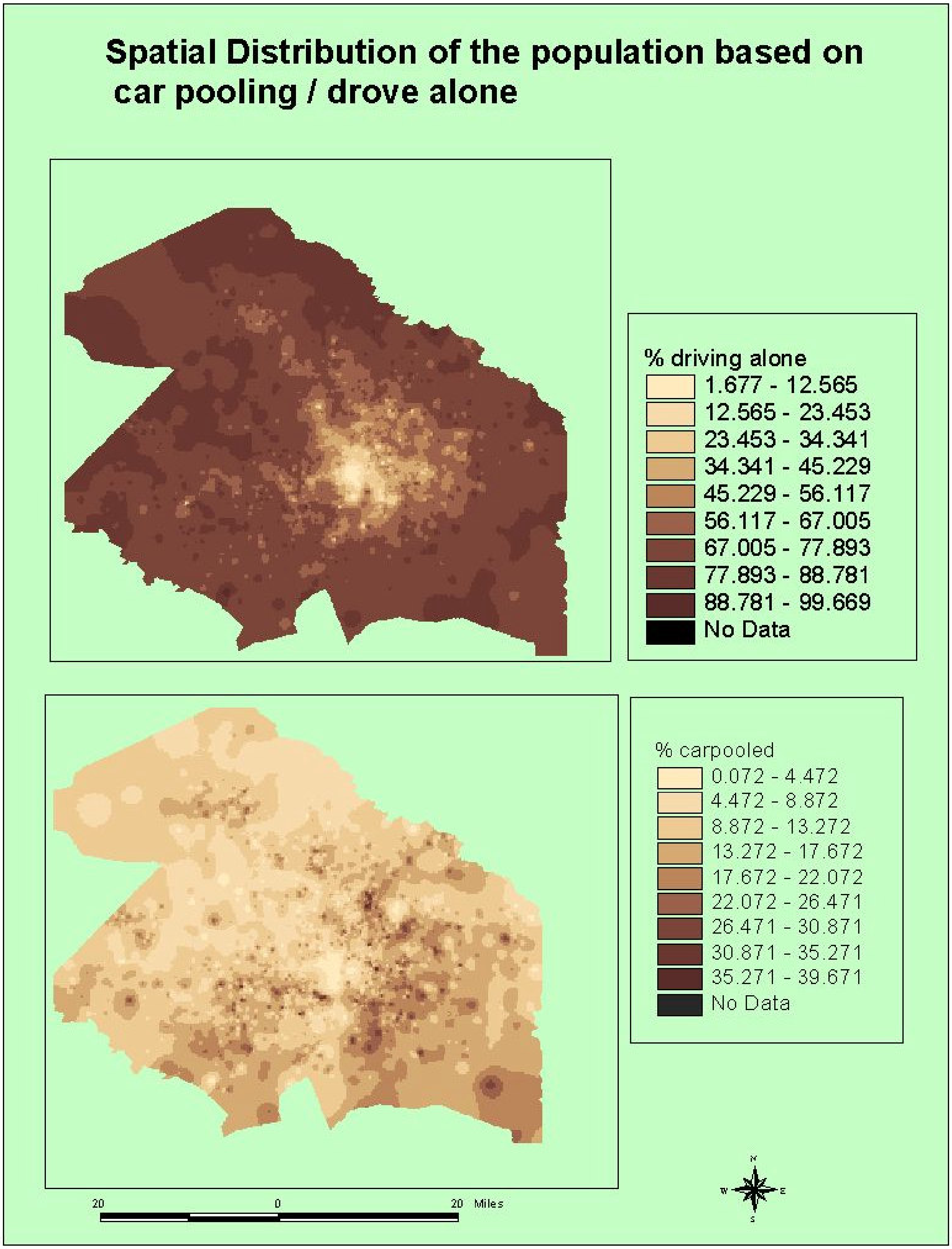
3. Carpooling/Driving Alone:

D.C. Metropolitan:

It is observed that the preference to drive alone gets higher away from central part of DC. (Refer to Map 4A, pg.27) Areas close to central and western D.C. Metropolitan region indicates a low preference to drive alone. However that same region does not show a car-pooling preference either. It could be due to lack of private car ownership or heavy dependence on bus or metro for transportation to work Central D.C. still shows low preference for car-pooling but away from central D.C. towards the west and some parts of P.G. County there is an increase in percentage of people car-pooling

Over all car-pooling is low in the rest of the region with Fairfax County and Montgomery County showing the least preference. The southeastern part of Fairfax County close to the beltway and along Richmond highway shows higher percentage of carpooler's. People traveling through the beltway may carpool for convenience.

MAP 4A


Spatial Distribution of the population based on car pooling / drove alone
% driving alone
1.677 - 12.565
12.565 - 23.453
23.453 - 34.341
34.341 - 45.229
45.229 - 56.117
56.117 - 67.005
67.005 - 77.893
77.893 - 88.781
88.781 - 99.669
No Data
% carpooled
0.072 - 4.472
4.472 - 8.872
8.872 - 13.272
13.272 - 17.672
17.672 - 22.072
22.072 - 26.471
26.471 - 30.871
30.871 - 35.271
35.271 - 39.671
No Data
20
0
20 Miles

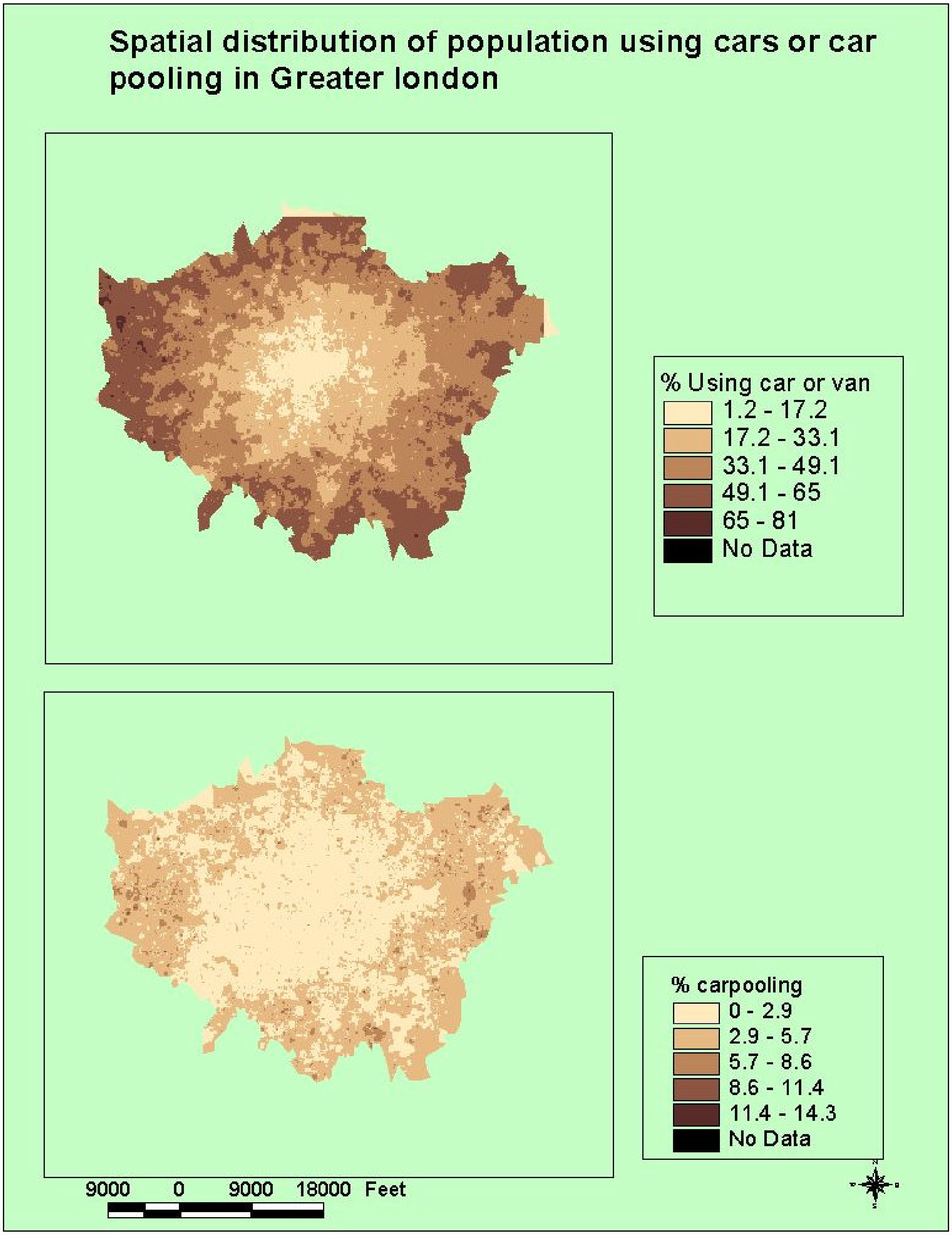
London:

Cars form a very predominant mode of transportation both in the suburbs and the rest of the region, as it is a very convenient mode of transportation. However closer to central London, delay due to traffic congestion, limited parking spaces and also parking spaces being at grater distances from destination, cars are relatively less advantageous to other modes of transportation

And this feature is very clear from the map that demand for driving alone or car-pooling increases with distance from central London. However Car-pooling tends to be very low throughout Grater London. (Refer to Map 4B pg. 29). People prefer bus or tube to carpooling.

Thus it is clear that in Greater London bus, car and tube are the most used mode of transportation to work. And in central London the predominant mode of transportation is bus and foot.

MAP 4B



Spatial distribution of population using cars or car pooling in Greater london
% Using car or van
1.2 - 17.2
17.2 - 33.1
33.1 - 49.1
49.1 - 65
65 - 81
No Data
% carpooling
0 - 2.9
2.9 - 5.7
5.7 - 8.6
8.6 - 11.4
11.4 - 14.3
No Data
9000 0 9000 18000 Feet

4.**Socio economic Characteristics**:

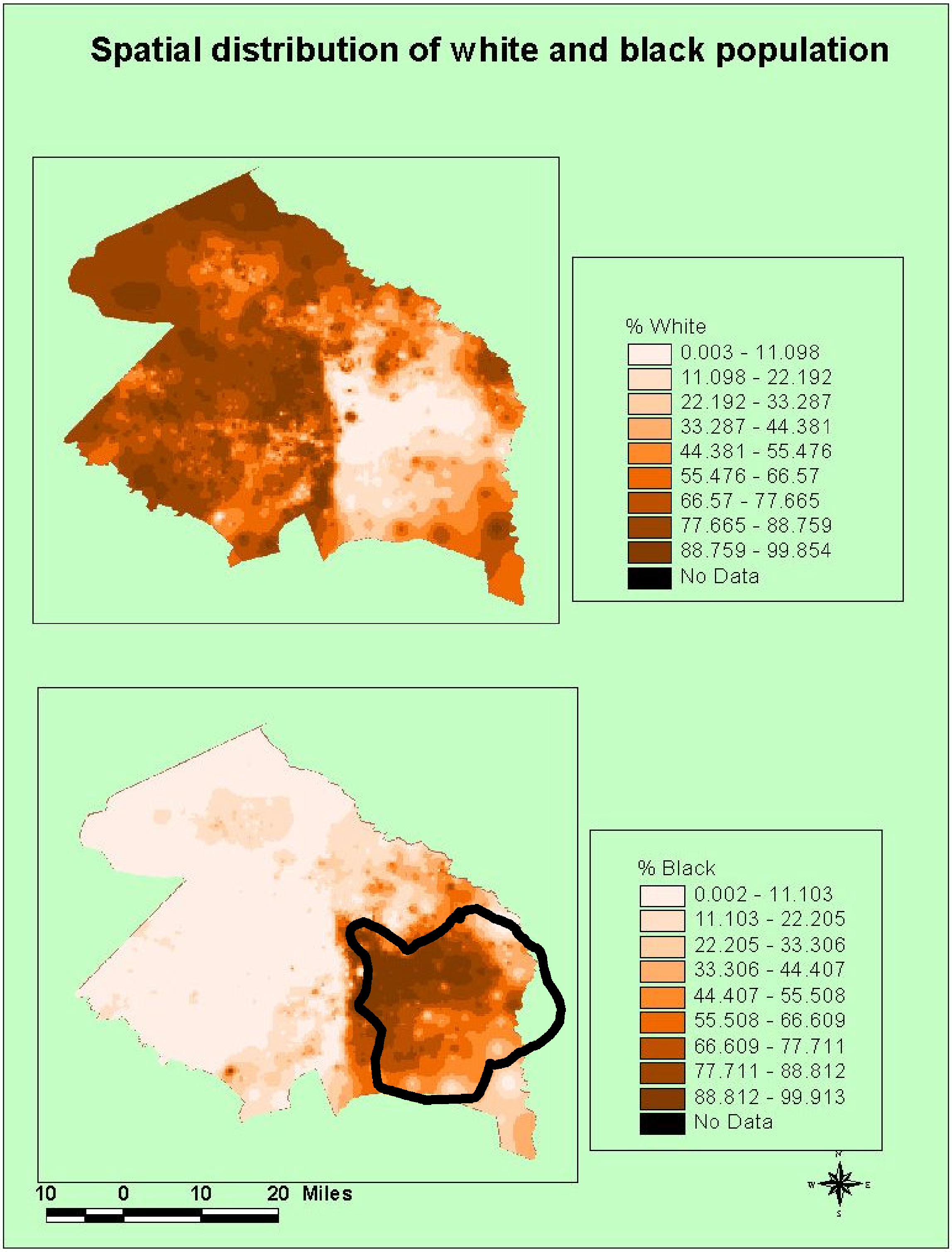
Race:

***D.C. Metropolitan Region*:**

Three categories were considered for analysis – White, Black and Asian. The following map shows the spatial distribution of the white and the black population in the D.C. area. (Refer to map 5Aa and 5Ab pg. 31, 32).

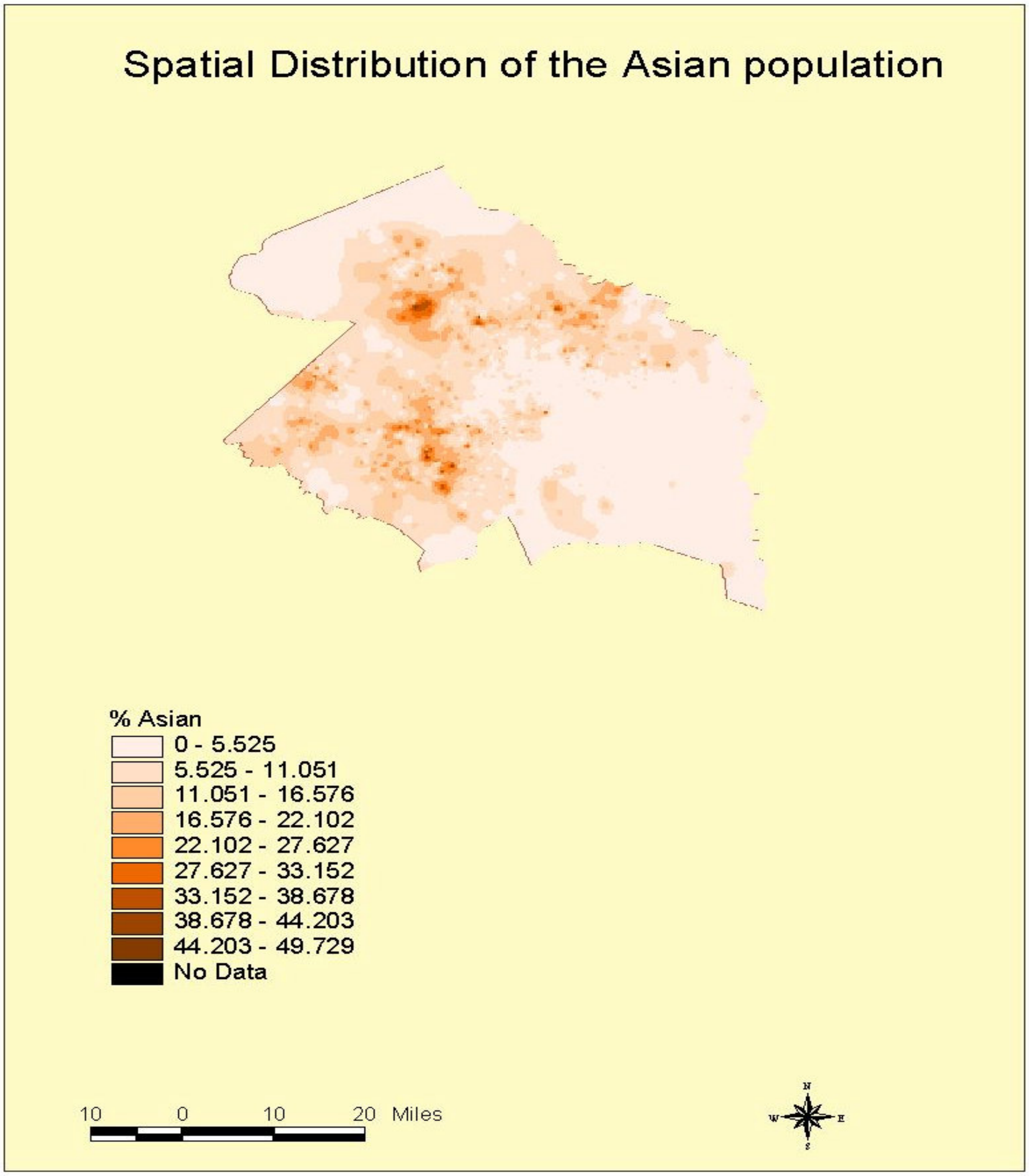
High-density black population is mainly found in eastern part of D.C. and P.G. County. Whereas high-density white population is found is Fairfax, Montgomery county. Density patterns show that there are block groups, which have 100% black or white population. Thus it is clear that the population is segregated on the bases of race especially in terms of white and black population. However Asian population is more spread out in the western part of D.C. metropolitan region.

MAP5Aa



Spatial distribution of white and black population
% White
0.003 - 11.098
11.098 - 22.192
22.192 - 33.287
33.287 - 44.381
44.381 - 55.476
55.476 - 66.57
66.57 - 77.665
77.665 - 88.759
88.759 - 99.854
No Data
% Black
0.002 - 11.103
11.103 - 22.205
22.205 - 33.306
33.306 - 44.407
44.407 - 55.508
55.508 - 66.609
66.609 - 77.711
77.711 - 88.812
88.812 - 99.913
No Data
10 0 10 20 Miles

MAP 5Ab

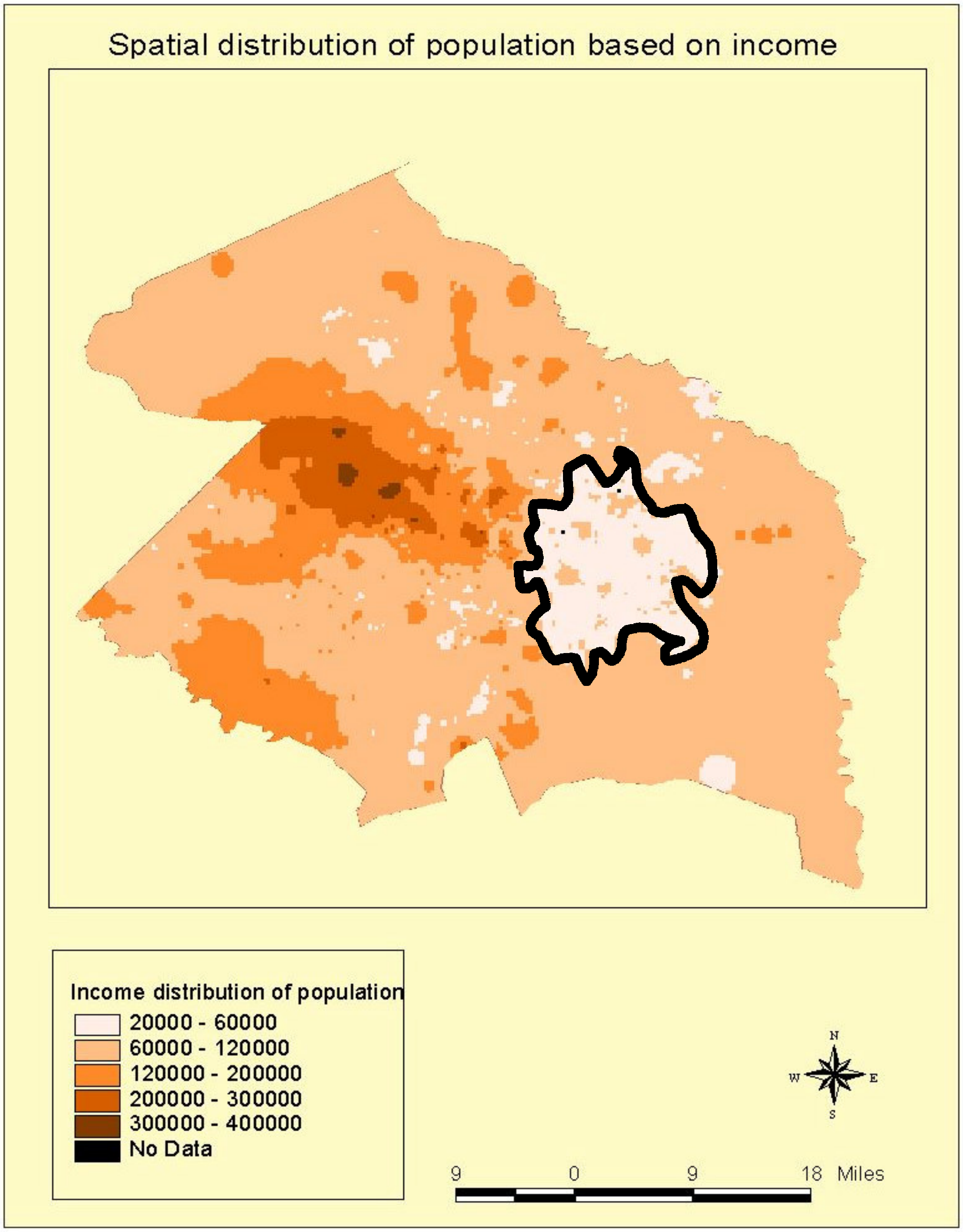

Spatial Distribution of the Asian population
% Asian
0 - 5.525
5.525 - 11.051
11.051 - 16.576
16.576 - 22.102
22.102 - 27.627
27.627 - 33.152
33.152 - 38.678
38.678 - 44.203
44.203 - 49.729
No Data
10 0 10 20 Miles

Income:
***D.C. Metropolitan*:**

The following map (map 6A pg.26) shows the dispersion of mean household income in the Washington D.C. area.

The average highest income level in the DC metropolitan region is around the $370,000.00. The area near the border of Fairfax County, Falls church City and Montgomery county area the areas, which show very high income. This is followed by other areas within Fairfax county and Montgomery county. Interestingly the white patches indicating low-income areas seems to match with the area predominantly having a black population, which is also the same area where the mode of transportation to work was mainly bus and not car. That area is circled in black in Map 5Aa and Map 6A.

MAP 6A


Spatial distribution of population based on income
Income distribution of population
20000 - 60000
60000 - 120000
120000 - 200000
200000 - 300000
300000 - 400000
No Data
N
W
E
S
9
0
9
18 Miles

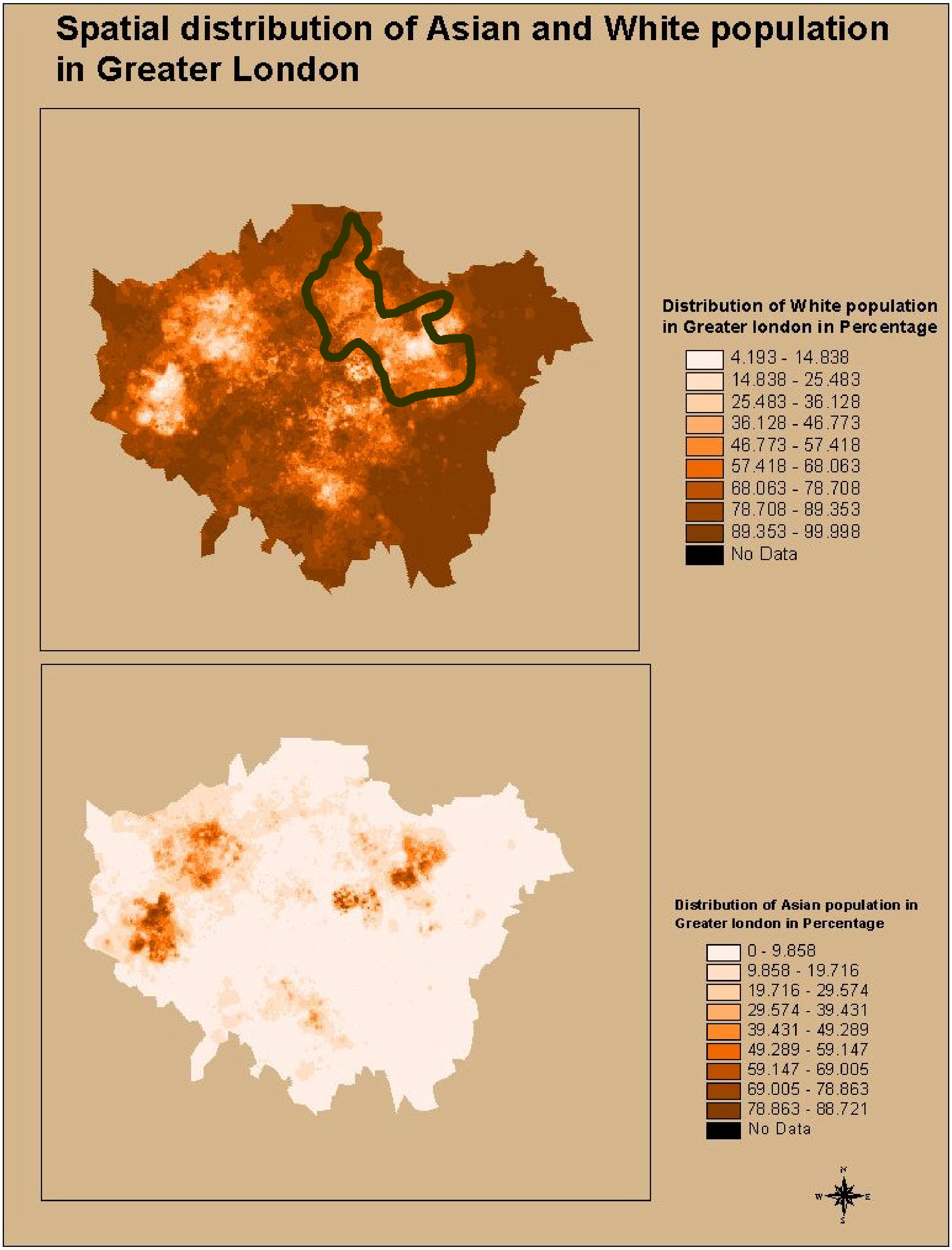
Race:

Greater London:

As mentioned earlier the three races considered here were White, Black and Asian. Asian in this analysis represents Indian, Pakistanis and Bangladeshis. (Refer to map 5Ba and 5Bb pg. 36, 37).

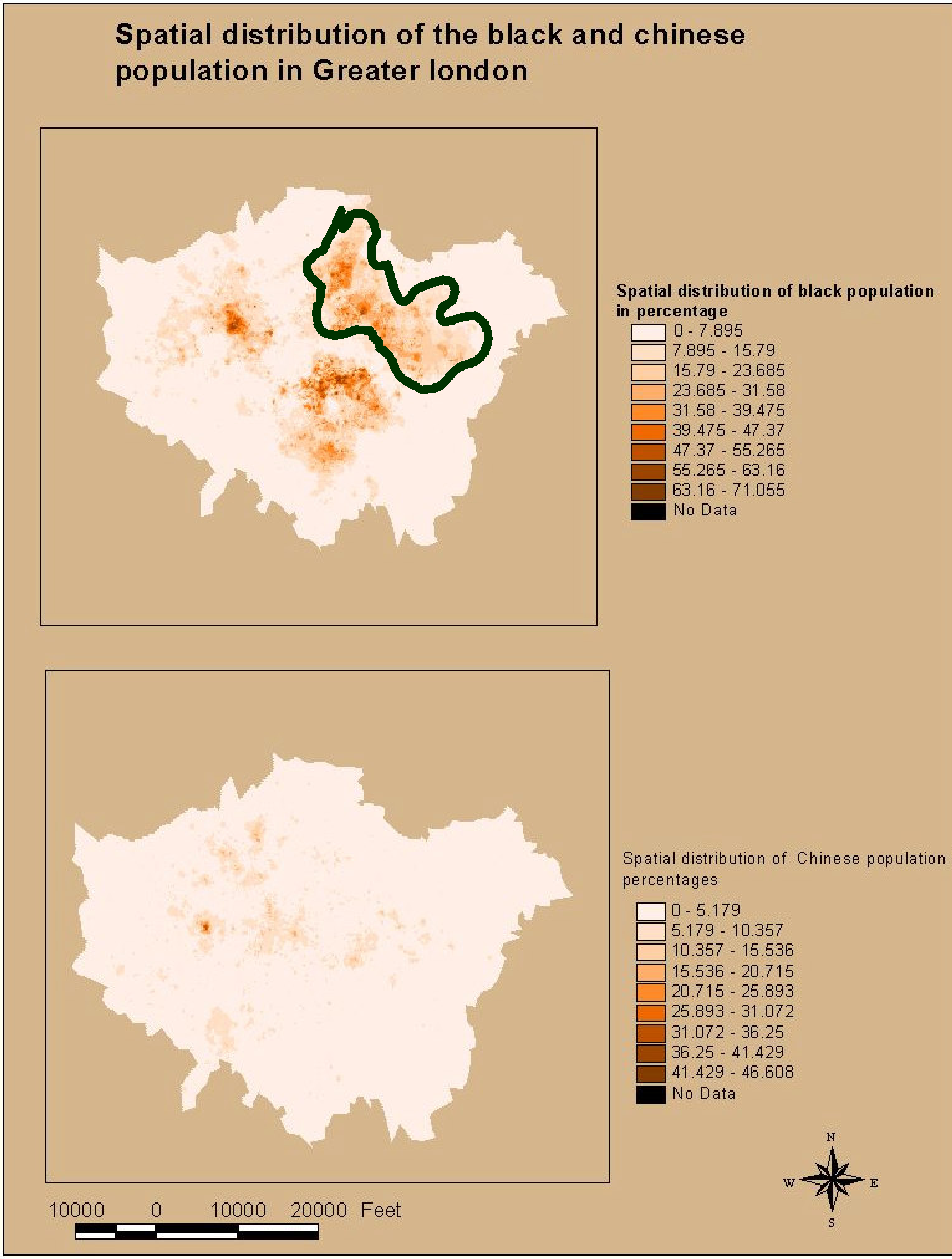
The map below shows that white population is the predominant one, with many areas showing 100 % white population. Asian here are found in small cluster with 90% Asians found in some output areas in outer London. Similarly blacks are also found in small clusters around central London and within inner London.

MAP 5Ba



Spatial distribution of Asian and White population in Greater London
Distribution of White population in Greater london in Percentage
4.193 - 14.838
14.838 - 25.483
25.483 - 36.128
36.128 - 46.773
46.773 - 57.418
57.418 - 68.063
68.063 - 78.708
78.708 - 89.353
89.353 - 99.998
No Data
Distribution of Asian population in Greater london in Percentage
0 - 9.858
9.858 - 19.716
19.716 - 29.574
29.574 - 39.431
39.431 - 49.289
49.289 - 59.147
59.147 - 69.005
69.005 - 78.863
78.863 - 88.721
No Data

MAP 5Bb



Spatial distribution of the black and chinese population in Greater london
Spatial distribution of black population in percentage
0 - 7.895
7.895 - 15.79
15.79 - 23.685
23.685 - 31.58
31.58 - 39.475
39.475 - 47.37
47.37 - 55.265
55.265 - 63.16
63.16 - 71.055
No Data
Spatial distribution of Chinese population in percentages
0 - 5.179
5.179 - 10.357
10.357 - 15.536
15.536 - 20.715
20.715 - 25.893
25.893 - 31.072
31.072 - 36.25
36.25 - 41.429
41.429 - 46.608
No Data
N
W
E
S
10000 0 10000 20000 Feet

Income :

Greater London:

As mentioned as earlier in case of London the data representing income of the socio economic status was available in different class groups with each group representing a particular type of work. For Ex.

"AB" Stood for Higher and Intermediate/managerial/administrative and professional.

"C1" –supervisory; clerical; junior managerial/administrative and professional

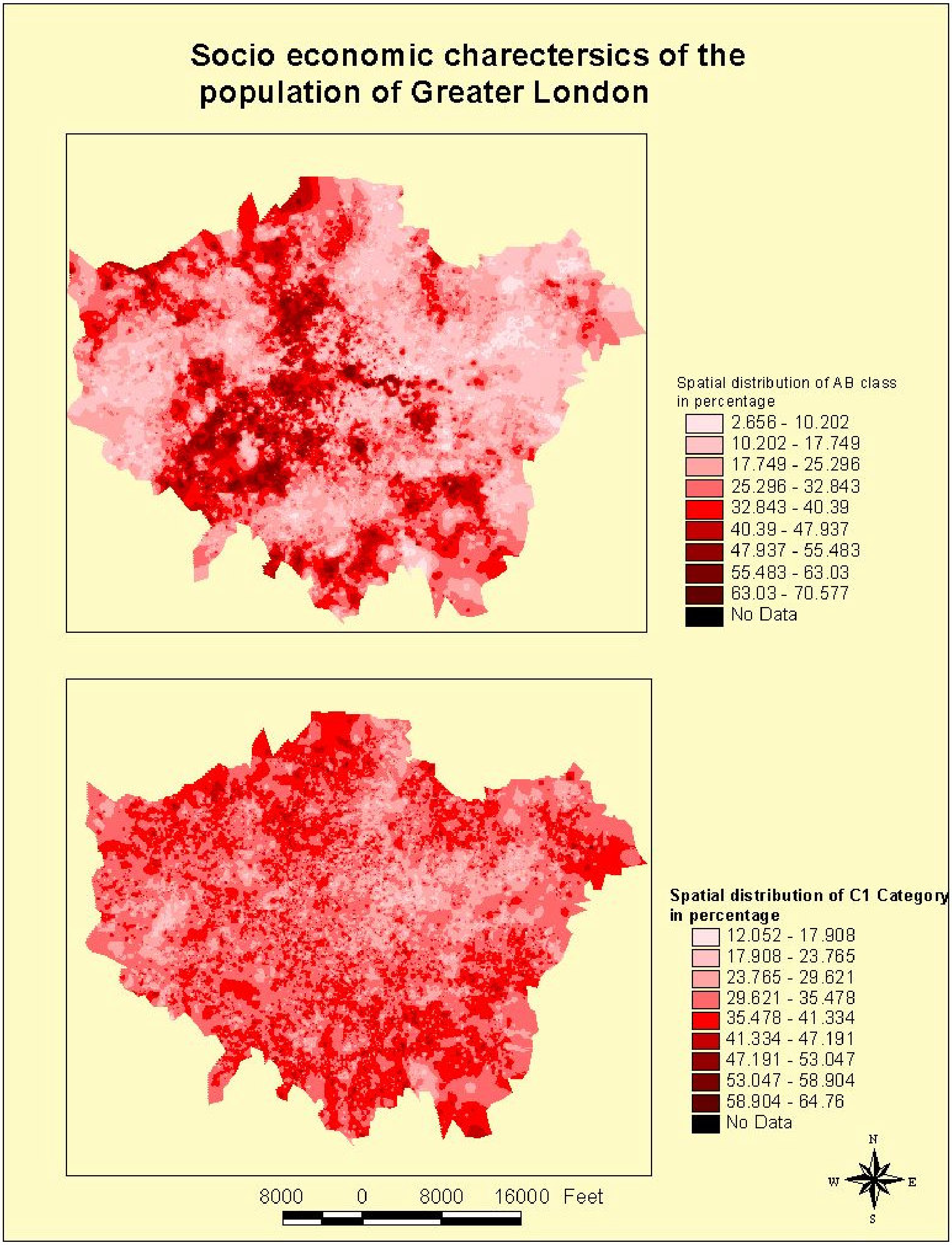
"C2" - Skilled manual workers

"D" Semi skilled and unskilled annual workers

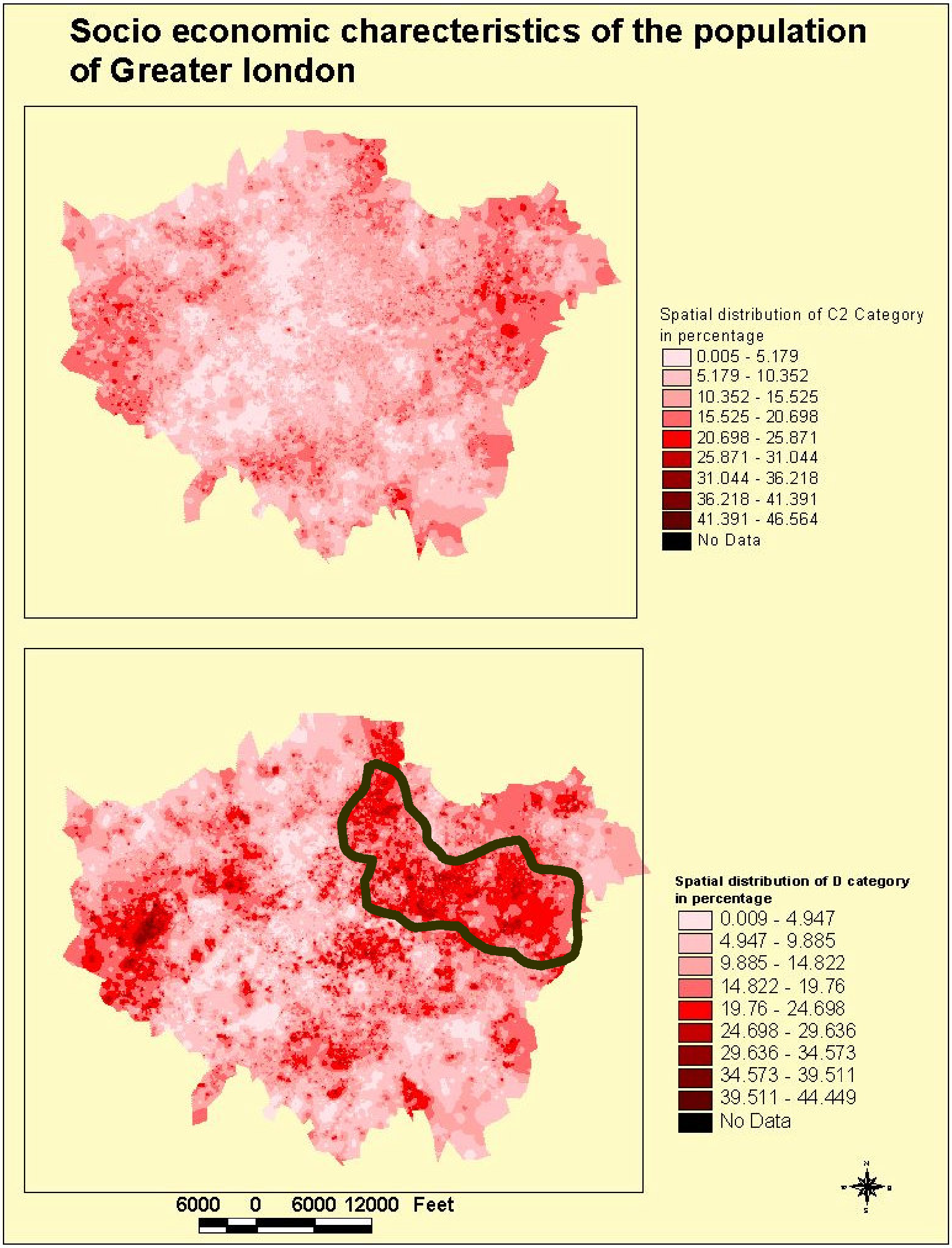
"E" On state benefit; Unemployed lowest grade workers.

Please refer to map **6Aa** and **6Bb** for the analysis (pg.39, 40). AB class is the most affluent class followed by C1 and C2. There is a slight indication that income and race are closely related here. Here we see that area has high concentration of black and also class "D" workers. The area has been circled in the map. AB type of work falls in the same place where the predominant population is white. The C2 category of working population is more evenly spread out. They constitute about 25% to 30 % of the working population .AB class predominates central, southwestern, eastern and some parts of northern London. Within those areas it varies from 25% to 75%. C2 category is found mainly is eastern and western part towards the border of Greater London.

MAP 6Ba


Socio economic charectersics of the population of Greater London
Spatial distribution of AB class in percentage
2.656 - 10.202
10.202 - 17.749
17.749 - 25.296
25.296 - 32.843
32.843 - 40.39
40.39 - 47.937
47.937 - 55.483
55.483 - 63.03
63.03 - 70.577
No Data
Spatial distribution of C1 Category in percentage
12.052 - 17.908
17.908 - 23.765
23.765 - 29.621
29.621 - 35.478
35.478 - 41.334
41.334 - 47.191
47.191 - 53.047
53.047 - 58.904
58.904 - 64.76
No Data
8000 0 8000 16000 Feet
N
W
E
S

MAP 6Bb


Socio economic charecteristics of the population of Greater london
Spatial distribution of C2 Category in percentage
0.005 - 5.179
5.179 - 10.352
10.352 - 15.525
15.525 - 20.698
20.698 - 25.871
25.871 - 31.044
31.044 - 36.218
36.218 - 41.391
41.391 - 46.564
No Data
Spatial distribution of D category in percentage
0.009 - 4.947
4.947 - 9.885
9.885 - 14.822
14.822 - 19.76
19.76 - 24.698
24.698 - 29.636
29.636 - 34.573
34.573 - 39.511
39.511 - 44.449
No Data
6000 0 6000 12000 Feet

Conclusion:

From the above analysis it is clear from the maps that there is slight connection between preference for the mode of transportation and socio economic characteristics of the population especially in the southeastern part of the D.C. region. Travel patterns indicate that preference for public transit over private transit does exist along the metro lines and along the bus routes.

In central London and inner London however we find a preference for tube, trains over car. This is mainly because of the congested downtown area and limited parking space. Hence the socio-economic factors do not play a predominant role in deciding the mode of transportation in London.

Thus it is clear that residents mainly living close to metro use metro and bus to communicate to work. People residing in central London walk to their work place. Thus people do prefer public transit to cars if the metro stop is at walk able distance. With the extension of the metro system along the Dulles corridor we could expect more metro riders. With the continuous traffic jams along the beltway I- 495 and major transportation corridors I- 66, I- 270, Rt-50 especially during peak hours, a better developed public transit system would certainly save more time and energy for the working population.
People could use more than one transportation mode while going to work. A combination of car and metro or bus and metro .For those who live at a driving distance of 15 min from the metro stations might consider this alternative. Besides these factors could be kept in mind while deciding the future metro stops or bus routes. It could also be used for modeling demand in the near future.

Thus we can see how GIS can be effectively used to help in transportation planning and in predicting public transit rider ship and also analyzing its socio characteristics It helps to determine current transit rider ship with the help of spatial analyst. The above analysis can be carried on forward .We could use GIS to model transit ridership based on factors like proximity (distance to stations); frequency (headways at serving stations); and accessibility (regional connectivity of serving stations) on transit ridership. In short, we could quantify the effects of these variables on transit ridership in our analysis by regressing on selected household characteristics and these three transit quality measures.

An important phase of transportation planning is "assessment of travel demand". Si nce demand is the basis for i) identification of suitable technology, ii) working out the supply requirement and also iii) deriving various other components such as financial feasibility, system sustainability etc. emphasis is given in this work to assess the travel demand.

Travel demand models are used to predict changes in travel and utilization of the transportation system in response to changes in land-use, demographics, socio-economic conditions. Data collection is a major part of the work and converting them from different scales to the required scale is a time consuming process. The available data are in paper format with different departments and organizations; and, most of the times they do not meet the requirements due to variations in format. This problem is prevalent in most of the organizations. Geographical Information System (GIS) is a preferred platform, because the data attributes are associated with topological object (point, line or polygon) . In GIS, information's are identified according to their actual locations. The graphical display capabilities allow visualization of different locations of traffic generators, network and routes. The use of GIS in transportation planning enhances the visualization aspect and facilitates the development of decision modules for use by the transport planners.

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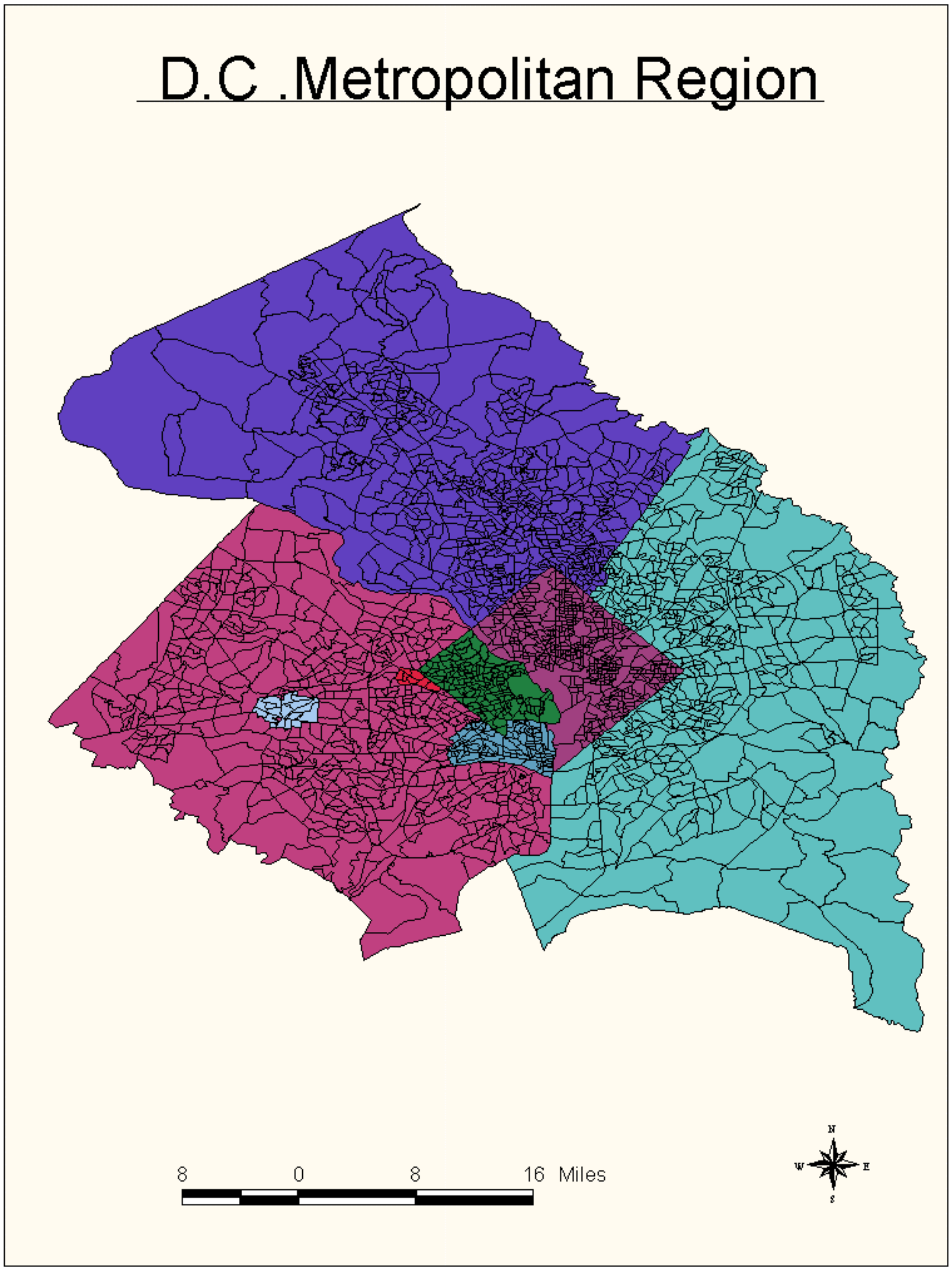
Appendix

Maps 1 A :



Map 1B