Drive-Time Analysis of West Virginia Hospitals using Network Analyst

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Abstract

The focus of this project is to demonstrate how GIS is used to show 30 minute drive-time analysis for West Virginia hospitals that are classified as Acute Care, Long Term Acute Care or Critical Access. Data used in this project included two road files, from TIGER/Census that, joining the two files provides necessary information such as length, speed limits and the definition of each CFCC classification. The new road file allows travel time formula to be demonstrated. The road shapefile was taken into ArcCatalog where we created the network dataset. Another data source was an excel file identifying the hospital locations. These data are provided by the WV Office of Health Facility Licensure and Certification and the United States Geological Survey which also provides the latitude and longitude coordinates. Network Analyst is then used to produce the 30 minute polygons that represent each hospital site in West Virginia.

Introduction

The West Virginia Health Care Authority has two primary goals: to constrain the rising cost of health care and to assure reasonable access to necessary health services. GIS plays a major role supporting these goals on a daily basis. However, the secondary purpose of this project was the focal point of this case study. ESRI products, including ArcGIS and ArcGIS Network Analyst, are used to calculate the drive-time formula and produce the polygons that illustrate the final results.

The aim of this project is to illustrate the drive-time analysis as you travel 30 minutes towards each hospital in West Virginia. Overall, there are 66 hospitals in West Virginia but for this project only the hospitals that are Acute Care, Long-Term Acute Care and Critical Access criteria are included. The WV Health Care Authority's definitions for Acute Care and Critical Access are:

Acute Care Hospital – Inpatient hospital care provided to patients requiring immediate and continuous attention of short duration.

Long-Term Acute Care Hospital – An acute care hospital that cares for patients who have been in an intensive care or short-term acute care setting that requires an extended length of stay (greater than 25 days).

Critical Access Hospital – A hospital designated as such by the West Virginia Office of Rural Health Policy in conformance with the requirements of the Medicare Rural Hospital Flexibility Program.

There are 36 Acute Care hospitals, 2 Long-Term Acute Care hospitals and 18 Critical Access hospitals that are designated Critical Access in West Virginia. The Acute Care Hospitals and Long-Term Acute Care Hospitals are located in urban areas while the

Critical Access Hospitals are located in rural areas. The majority of the Acute Care Hospitals and Long-Term Acute Care Hospitals are located in the southern and western part of West Virginia while there are hospitals scattered in the northern panhandle and northern part of the state. The Critical Access Hospitals are located primarily in the mountain regions of the state with a few scattered in the eastern panhandle.

It is interesting to note that there is a Critical Access hospital located in Jefferson County, which is about 45 minutes to the north of Washington, D.C. This project examines the 30 minute drive-time analysis towards each hospital and also the analysis shows where gaps exist throughout West Virginia because not every county has a hospital.

Background

We implemented this project to evaluate how well the 36 Acute Care, 2 Long-Term Acute Care and 18 Critical Access Hospitals are serving their service area within 30 minutes. These hospitals were geocoded correctly or as close by as possible for the drive-time analysis to be accurate. It took experimenting and patience, but once the closest latitude and longitude coordinates were found, only then could the process begin to produce the polygons that would demonstrate the drive-time analysis.

Methodology & Results

The dataset used to create the hospital symbols is a combination of addresses provided by a state agency and latitude and longitude coordinates provided by the United States Geological Survey. This dataset includes the hospital, address, city, state, zip code, county, administrator, phone number and latitude and longitude. Past experiences with geocoding the hospitals would have required that StreetMap would have been used. However, with the coordinates I was able to attain coordinates from the USGS's website and to go into ArcMap and select the Tools menu->Add XY Data. Once there I selected the database table I wanted and set the X and Y coordinates and made sure that the coordinate system was set on North American Datum. After that was done for both the Acute Care and Critical Access Hospitals it was time to focus on the roads.

After researching and experimenting, the road shapefile used was the TIGER/Census shapefile. This shapefile was selected because it had road length included. It was missing speed limits, which is a key part of Network Analyst. More research was done and an article titled 'Coverage Assessment Using Census 2000 Tiger Roads' written by Mike Price and John Price explained how they were able to join the CFCC file that had a description with what the CFFC classification means along with the speed limit. Using the same directions they provided in the formula I was able to do the same thing for the West Virginia road shapefile.

Figure 1: CFCC description

SPEED_LIMI	DISPLAY_CL	FCC
40	4	A00
40	4	A01
40	4	A02
40	4	A03
40	4	A04
40	4	A05
40	4	A06
40	4	A07
40	4	A08
0	9	A09
65	1	A10
65	1	A11
65	1	A12
65	1	A13
65	1	A14
70	1	A15
70	1	A16
70	1	A17
70	1	A18
0	9	A19
55	2	A20
55	2	A21
55	2	A22
55	2	A23
55	2	A24
60	2	A25
60	2	A26
60	2	A27
60	2	A28
0	9	A29
45	3	A30
45	3	A31
45	3	A32
45	3	A33

Figure 2: CFCC table with Speed Limits

With this file in place, a join can be done with the TIGER/Census file and CFCC file. The join is accomplished by taking the CFCC column in the TIGER/Census file and the CFCC column in the CFCC file and matching them together to produce an attribute table that now had length and speed limit in the same table. After creating a new column named TravelTime, and going through and using Select by Attributes to highlight those speed limits greater than zero that the formula could be calculated for the travel times:

$$[LENGTH] * (60/[SPEED\_LIMI])$$

The formula represents travel time in minutes equals the road length in miles times 60 minutes divided by the segment speed limit. For the speed limits that equal zero I followed what the article had said to do. I choose Select by Attributes again and this time

I selected speed limits that equal 0 and when I had those rows selected the following formula was inserted:

$$=9999$$

This was selected because more than likely these roads represent driveways, loops and other types of roads that do not have a posted speed limit.

SPEED_LIMI	DISPLAY_CL	FCC	TravelTime
25	5	A41	0.36
25	5	A41	0.49
25	5	A41	1.15
25	5	A41	1.08
25	5	A41	1.58
25	5	A41	0.92
25	5	A41	0.76
25	5	A41	0.32
25	5	A41	1.28
25	5	A41	0.24
25	5	A41	0.1
25	5	A41	1.63
25	5	A41	0.33
25	5	A41	1.57
25	5	A41	0.7
25	5	A41	0.71
25	5	A41	0.15
25	5	A41	0.09
25	5	A41	0.14
25	5	A41	1.37
25	5	A41	0.47
25	5	A41	1.85
25	5	A41	1.6
25	5	A41	1.15
25	5	A41	1.19
25	5	A41	0.06
25	5	A41	0.54
15	6	A51	0.62
25	5	A41	0.87
0	9	A74	9999
0	9	A74	9999
25	5	A41	0.64
25	5	A41	0.21
25	5	A41	0.77

Figure 3: TravelTime calculated in Attribute Table.

With the formula calculated and inserted into the attribute table it is time to bring up ArcCatalog. ArcCatalog is where you go to create the road network dataset that will be used in Network Analyst. After setting up the parameters that will be used in defining the

road network dataset, the road network is created and ready to be used in Network Analyst.

In ArcGIS the ._ND file is added. This is the file that has the original road shapefile, along with the network dataset shapefile that was created in ArcCatalog. These files are important as they need to be in place in order for Network Analyst to function properly. With the Network Analyst window opened New Service Area is selected and the Critical Access Hospital facilities are added. Then the Layer Properties dialog box is opened and the Analysis Settings tab is selected. The Default Breaks is set at 30 minutes and the direction is set at Towards Facility and there are no U-Turns allowed and the Ignore Invalid Locations box is checked. Then go back to the Network Analyst toolbar and click on the Solve button. It takes a few minutes but in the end the desired results are produced and then repeat the procedure for both the Acute Care Hospitals and Long-Term Acute Care Hospitals.

Figure 4: Acute Care hospitals after 30 minute drive-time analysis has been completed.
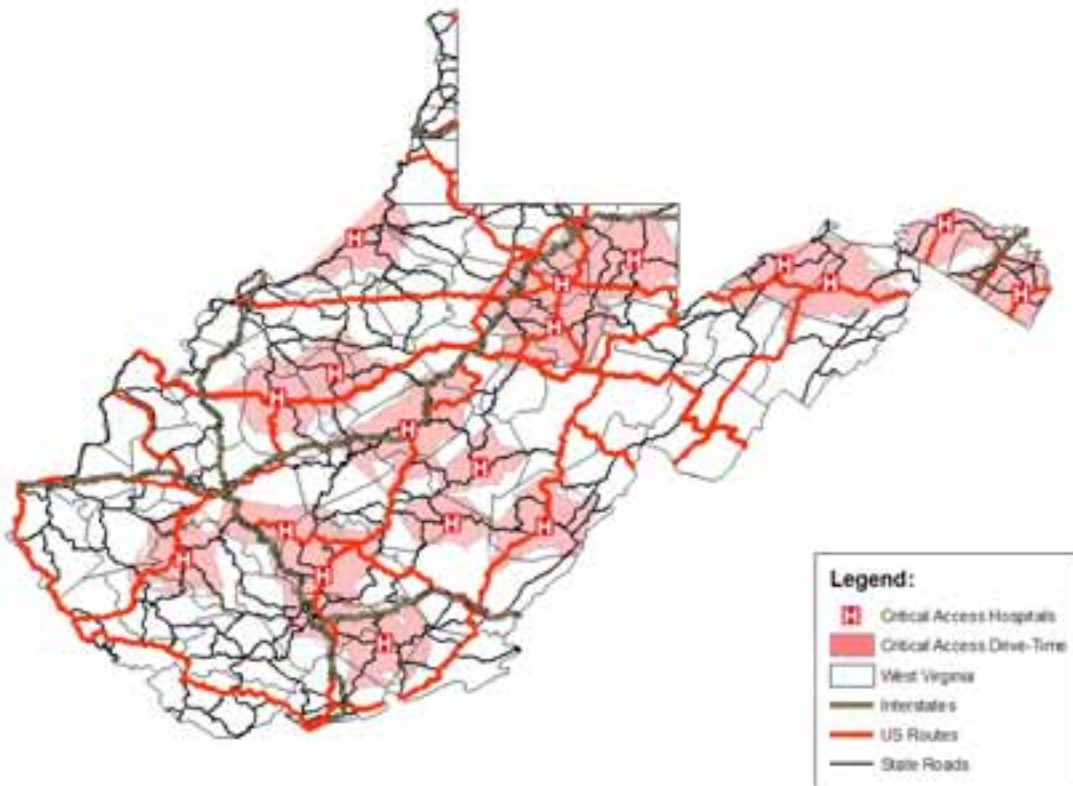
Figure 5: Critical Access hospitals after 30 minute drive-time analysis has been completed.

Conclusions

We raised some questions after this project was completed. First, are people who are on the borderline of the 30 minute drive-time polygon going to go to that hospital? Probably not because there are nearby hospitals that will be closer rather than make a full 30 minute drive to the hospital represented in the polygon. Second, why do some hospitals that are located nearby the state border have polygons that are shorter than other polygons? The answer used to be because each state has a different TIGER/Census file and thus it is harder to join files with the West Virginia road file because of file size. Now it can be done because each state that borders West Virginia can have a Travel Time formula calculated to their TIGER/Census file. After that process is complete then West Virginia and the states that border it road files are merged together to produce one road file that can give West Virginia hospitals located on the border the proper 30 minute drive-time distance analysis. Third, what about for those counties that do not have a hospital? More than likely they will go to the nearest hospital that is the closest to their location.

This project was very useful because it demonstrated to the agency decision makers where gaps of health care service exist throughout West Virginia. By using Network Analyst to demonstrate the drive-time analysis at 30 minutes, the project gives

decision makers an idea of how far people can go in 30 minutes to access necessary health care. Therefore, this project also supports the agency goal of assuming reasonable access to necessary health services.

Recently, the agency needed a 30 minute drive-time analysis for hospitals that provide birthing services. Based upon our experiences with this project, we were able to create a very effective illustration of those locations. With the successes of Network Analyst, there will be a need in the future for more projects that deal with Network Analyst.

References
Price, Mike, Price, John. "Coverage Assessment Using Census 2000 TIGER Roads." *ArcUser* July-September 2003. 54-58.

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