Access to Health Care

Lecture #24 | GEOG 510
GIS & Spatial Analysis in Public Health

Varun Goel

Outline

- Geography of Health Care Delivery
- Health Care Provision
- Health Care Services
- Access to Health Care
  - 5 As of Access

Geo of Health Care Delivery

- Focuses on interactions between populations and health care services
  - Describe, explain, understand, predict, intervene…
  - Often, focus on ability to access services and service use
  - But also…
    - How health care affects health
    - Why health care resources are located where they are
    - How health care systems adapt to change

Geo of Health Care Delivery

Demand for public services emanates from individuals, who, in aggregate, are continuously (though unevenly) dispersed across space, while most public services are distributed from discrete facilities with fixed locations.

– from Joseph and Phillips (1984)

Health Care Provision

- Formal health care
  - Provided by organizations through providers
    - Public, private, voluntary
    - Clinics, facilities, in-home
  - Provider generally receives payment for providing care

Health Care Provision

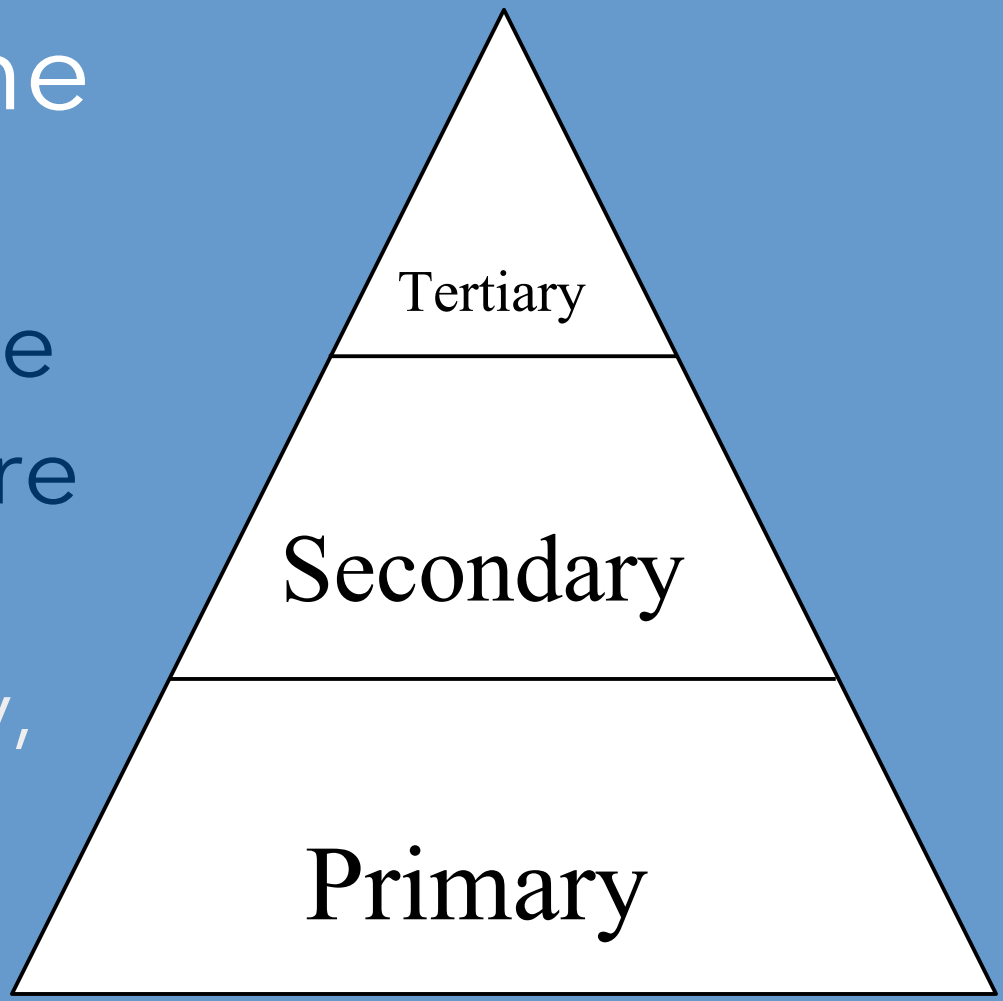
- Informal health care
  - Majority of care
  - Provided by families or communities
    - In-home, community settings
  - Care is not monetized
    - Has costs, however
  - Women provide more than half of all informal care
  - Youth caregivers

Health Care System

- Encompasses the state, people, providers, and payers… and how they interact to deliver health care services
  - State provides the context
  - People use the services
  - Providers deliver the services
  - Payers pay for the services

Health Care Services

- All health care services are not the same
  - Useful to categorize
  - Levels of health care provision
    - Primary, secondary, tertiary



Health Care Services

- Primary
  - Basic services
    - e.g., routine physician visits, prenatal care, immunization, outpatient, dental care
      - Preventative or restorative
    - Delivered in clinics, offices
      - General practitioner, family physician, nurse practitioner, physician assistant
    - Frequently used, thus must be available locally

Health Care Services

- Secondary
  - Acute or specialized services
    - e.g., advanced care, diagnostic imaging (MRI), specialist services (oncologist)
      - Restorative-focused
    - Delivered in hospitals, clinics, offices
      - Specialists (also general/family physicians)
    - Less frequently used, thus is not always available locally

Health Care Services

- Tertiary
  - Extremely advanced or specialized services
    - e.g., advanced care and highly specialized services (heart surgery, cancer treatment)
      - Restorative-focused
    - Delivered at large or research hospitals
      - Specialists
    - Infrequently used, therefore generally only available regionally

Health Care Services

- Other care settings
  - Long term care
    - e.g., nursing homes
  - End of life care
    - e.g., hospice
  - Mental/emotional care
    - e.g., psychiatric hospitals

Access (to Health Care)

- Potential and Realized
  - Potential access is the population's ability to gain entry to the system or the ability to use the health care services
  - Realized access is the population's actual entry to the system or utilization of the health care services

  For ease, I generally use the word "access" as *potential* access

Access (to Health Care)

- Difficult to define and characterize
  - Complex construct
    - e.g., financial, geographic, social, organizational components
    - More conceptual than operational?
  - Lack of barriers
  - Fit between what the health care system provides and what the population needs

Utilization (of Health Care)

- Another word for "use"
- Utilization is when the health care system is used
  - Can be measured via interactions
    - e.g., physician visits, days in hospital, MRI scans, etc.

Access

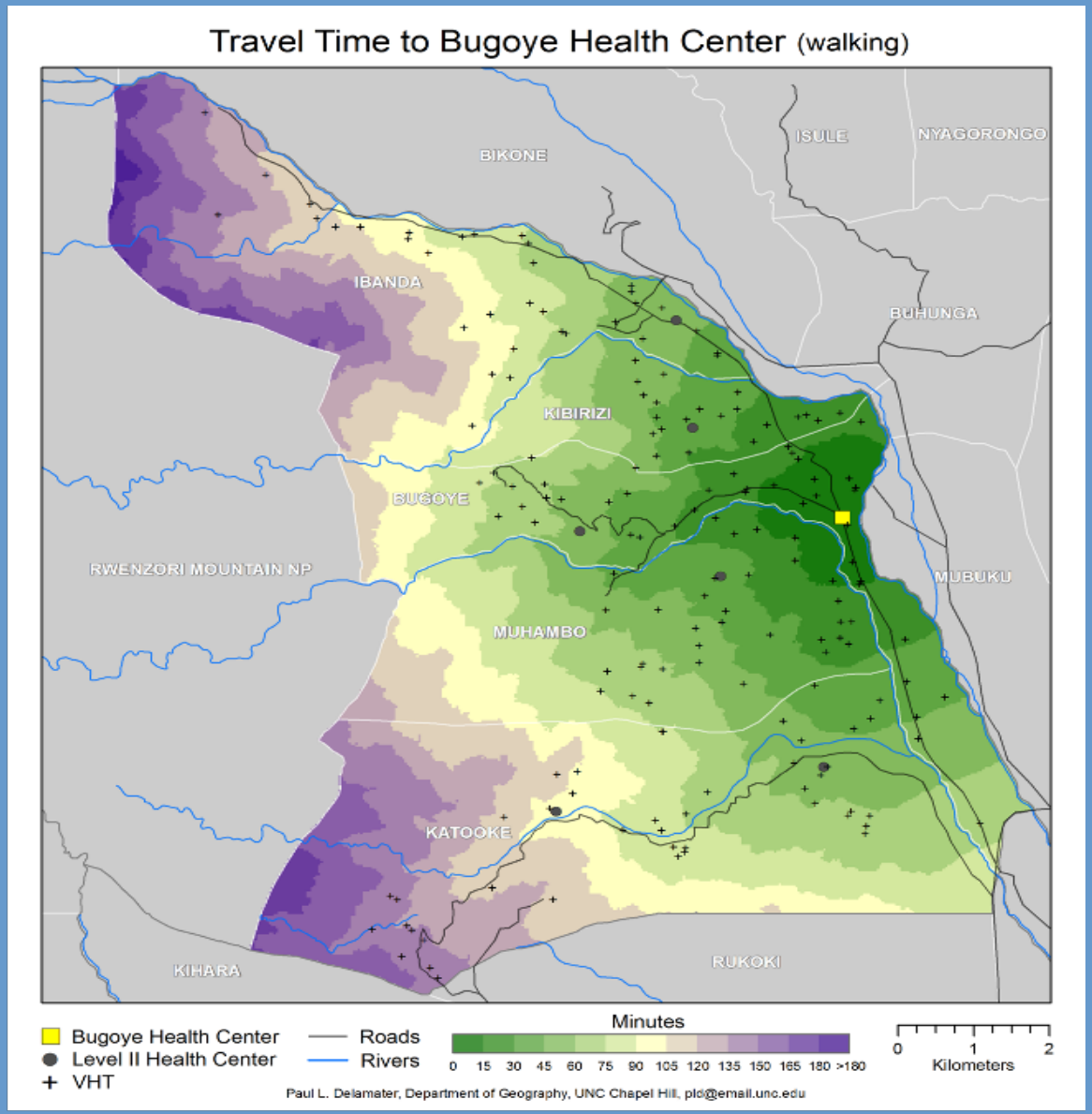
- Access as the potential to use health care services
  - Spatial dimensions
    - Accessibility
    - Availability
  - Aspatial dimensions
    - Affordability
    - Acceptability
    - Accommodation

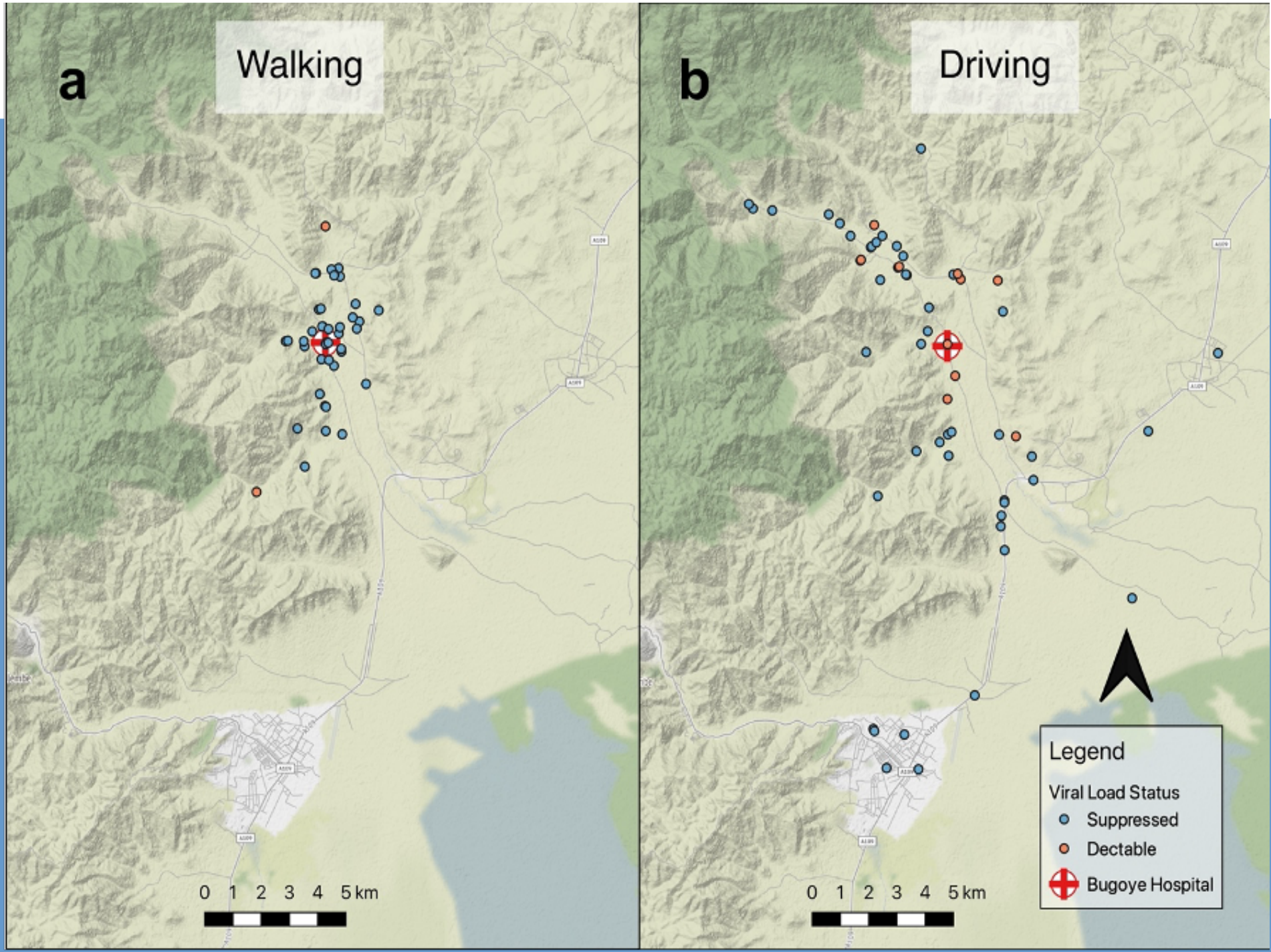
Accessibility

- The distance that must be overcome to access the service
  - To conduct a basic study of accessibility, you only need two inputs
    - Locations of people
    - Locations of services
      - But, helps to have road / transportation network connecting them!
      - Network Analysis supplemental lecture!

Measuring Distance

- Euclidean distance
  - Straight line distance, only requires coordinate locations
- Network (Travel) Distance
  - Distance along a network (e.g., roads)
    - Network restricts where travel can occur
- Travel time
  - Time to travel along a network
    - Needs network and speed of travel


Travel Time to Bugoye Health Center (walking)
BIKONE
ISULE
NYAGORONGO
IBANDA
BUHUNGA
KIBIRIZI
BUGOYE
RWENZORI MOUNTAIN NP
MUBUKU
MUHAMBO
KATOOKE
KIHARA
RUKOKI
Bugoye Health Center
Level II Health Center
VHT
Roads
Rivers
Minutes
0 15 30 45 60 75 90 105 120 135 150 165 180 >180
0 1 2
Kilometers
Paul L. Delamater, Department of Geography, UNC Chapel Hill, pld@email.unc.edu

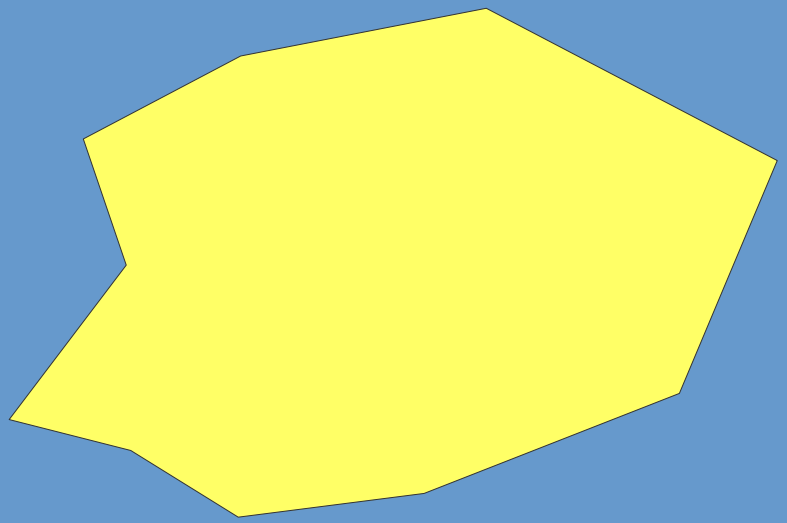

a
Walking
0 1 2 3 4 5 km
b
Driving
0 1 2 3 4 5 km
Legend
Viral Load Status
Suppressed
Dectable
Bugoye Hospital

Accessibility

- Distance to nearest facility as a measure of geographic accessibility
  - In a GIS, measure the distance for all people to nearest facility (based on residence)
    - Output is a line feature (the path) and measurement (in a table)
    - Map, graph, or table of result

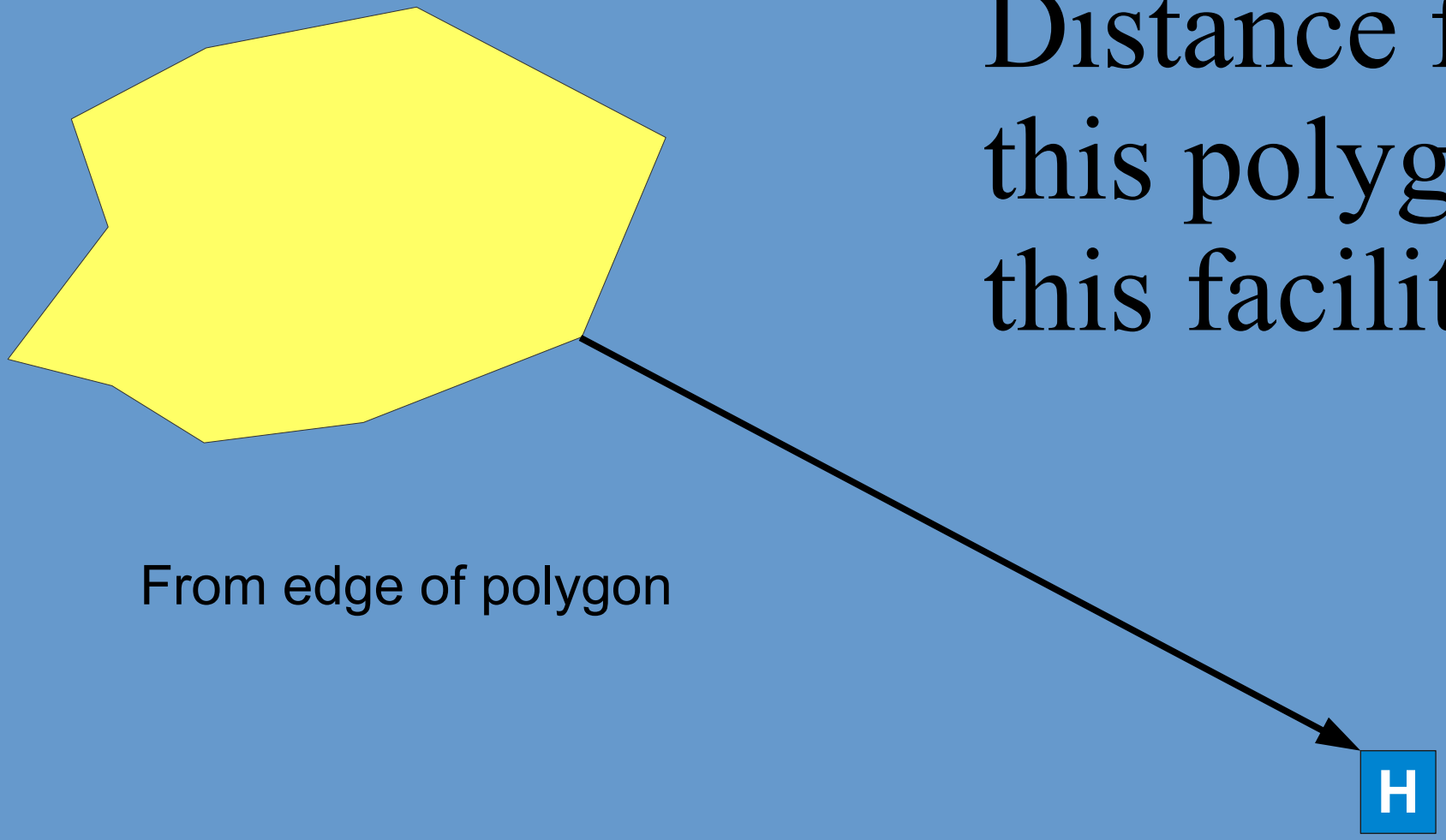
Accessibility

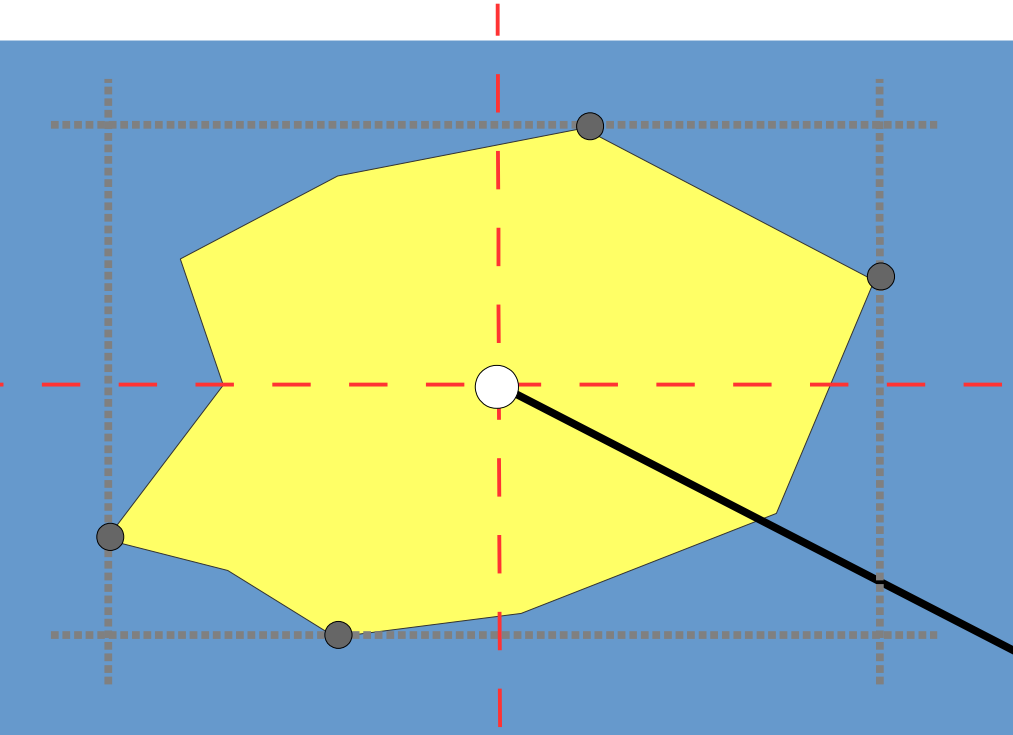
- Easy to conceptualize for individuals... but we are generally working with populations
  - Ecological data where each unit represents numerous people
    - We often don't know the exact location of all people within the unit
  - Goal is to capture the average distance for members of the population



Distance from this polygon to this facility?

Distance from this polygon to this facility?

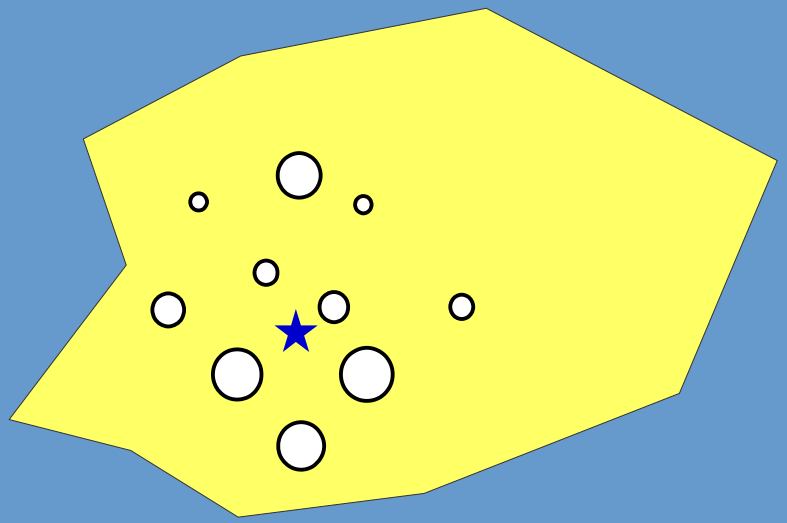




Distance from this polygon to this facility?

From geographic centroid
(closer to average?)

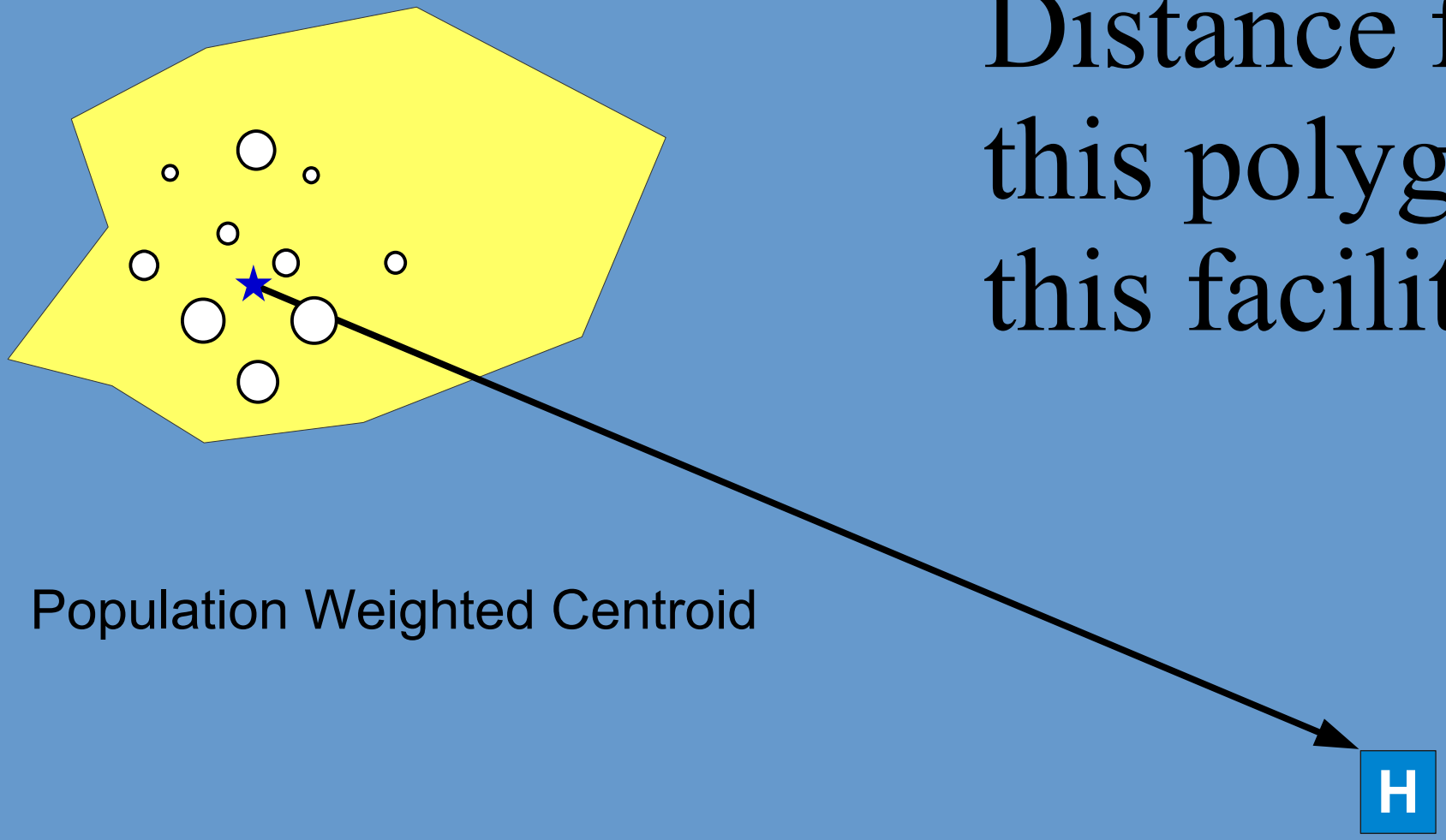
H



Distance from this polygon to this facility?

What about population distribution?

Distance from this polygon to this facility?



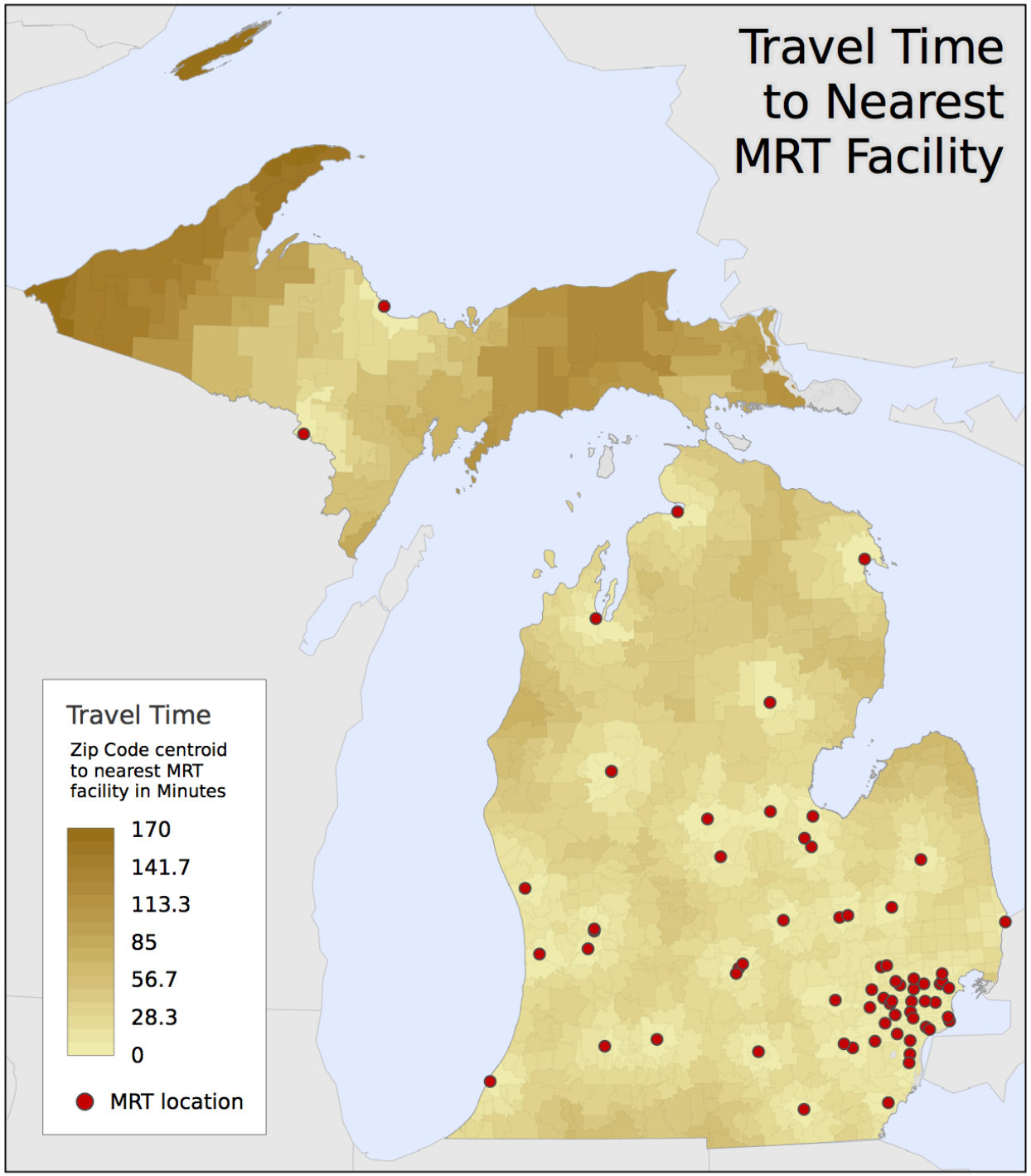
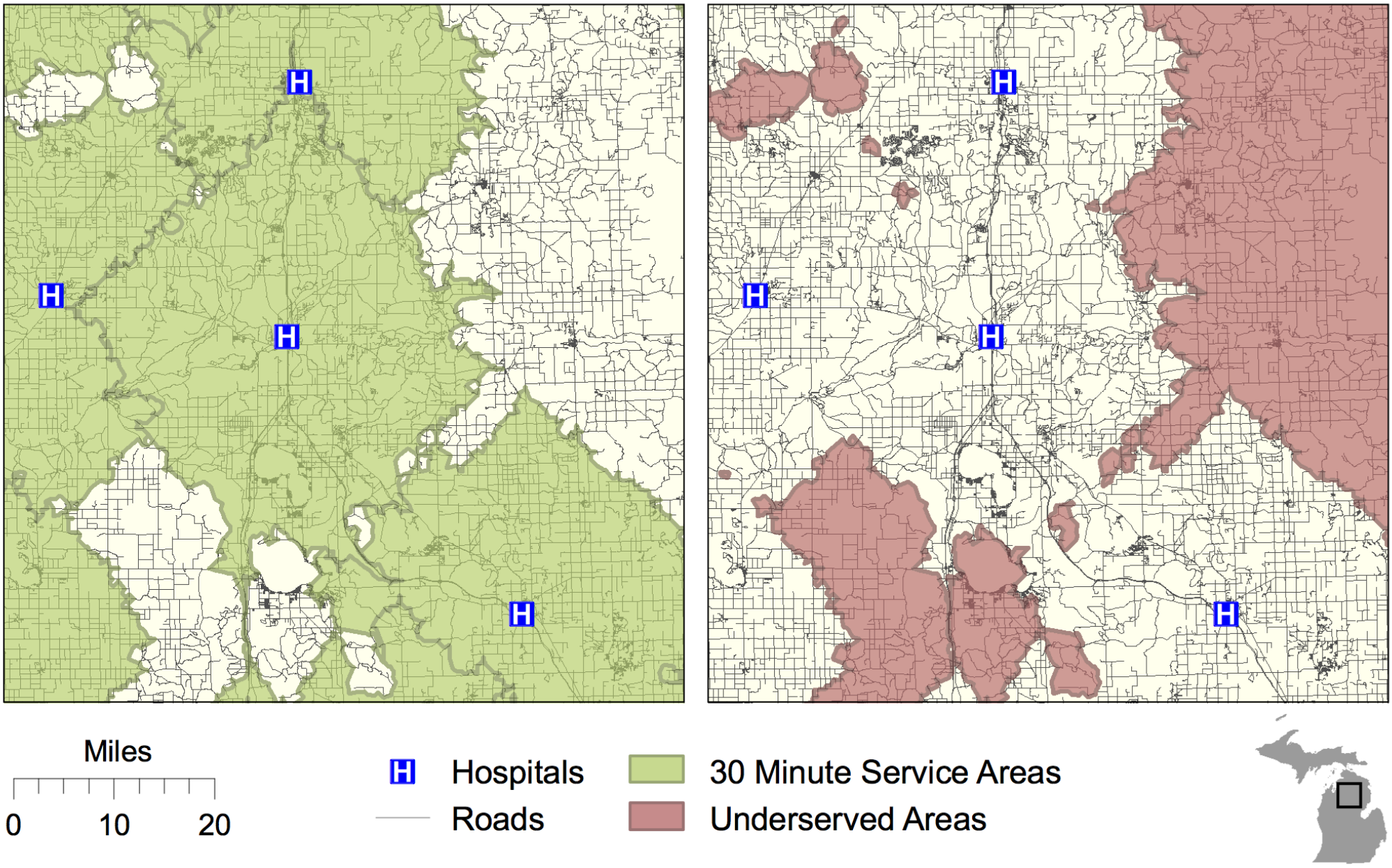

Travel Time
to Nearest
MRT Facility
Travel Time
Zip Code centroid
to nearest MRT
facility in Minutes
170
141.7
113.3
85
56.7
28.3
0
MRT location

Table 1. Geographic access to MRT services in Michigan. Travel time for the overall state population (**Pop**). **%** is percent of the population and **C%** is the cumulative percent (e.g., 93.04% of the overall population resides within 40 minutes or less of an MRT service location).

Minutes	Pop	%	C%
10	5,429,691	54.94	54.94
20	2,192,680	22.18	77.12
30	1,039,999	10.52	87.64
40	533,407	5.4	93.04
50	291,116	2.95	95.99
60	139,222	1.41	97.39
60+	257,525	2.61	100

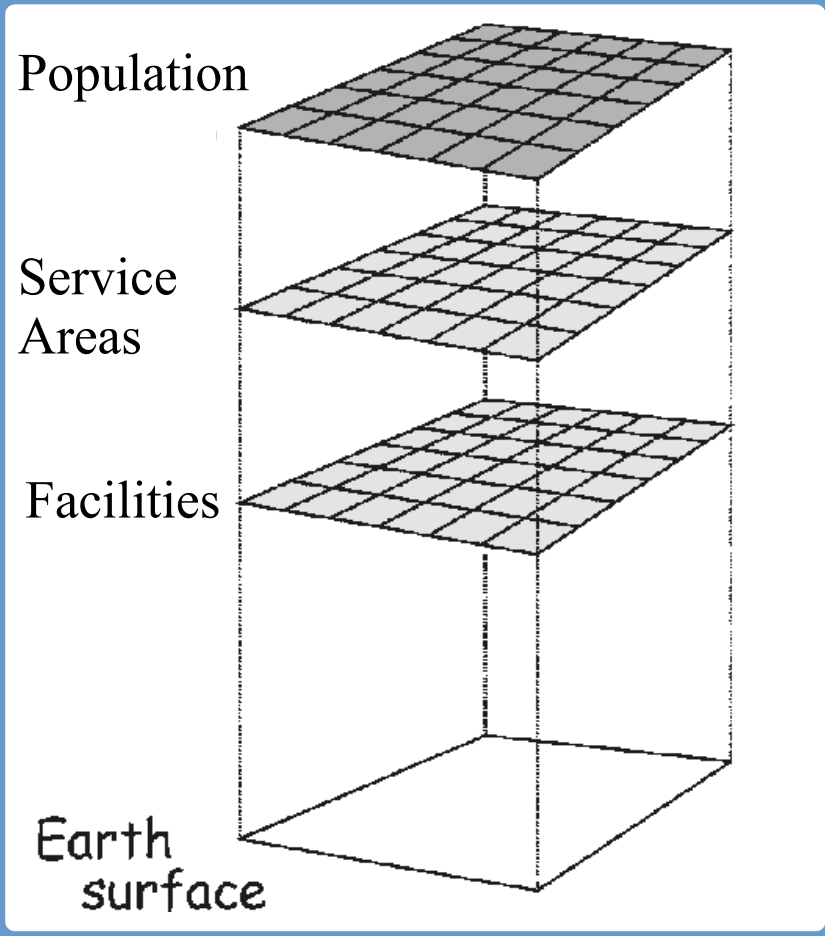
Accessibility

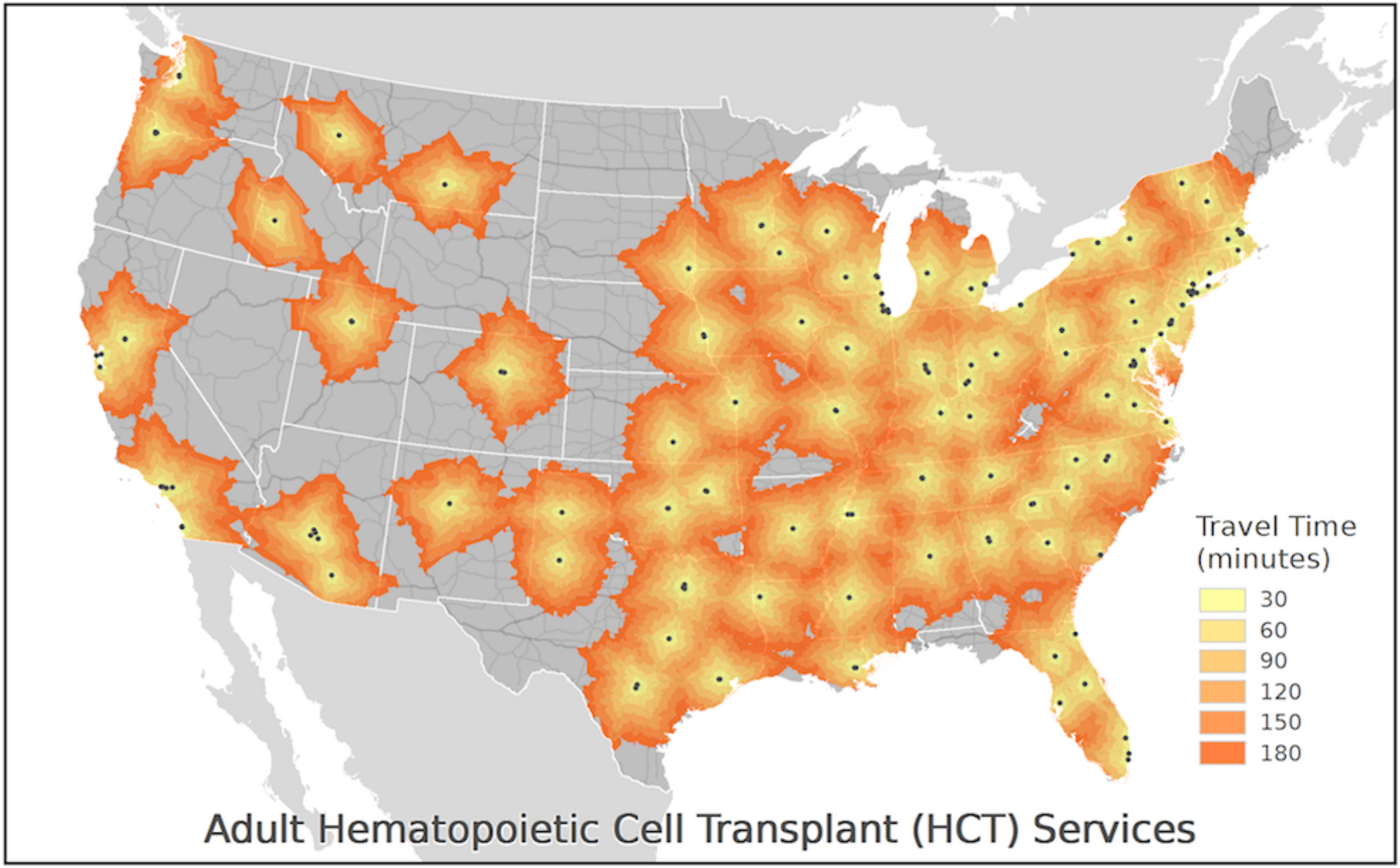
- Service Areas
  - Find all locations (on the network) that are within a certain distance or time from a point location
  - How it works
    - Trace all routes to specified distance/time
    - Mark "endpoint" along all edges
    - Create polygon (service area)


Miles
0
10
20
Hospitals
Roads
30 Minute Service Areas
Underserved Areas

Accessibility

- Service Areas
  - In the GIS, overlay population information to find out how far each is from the service
    - Map or create table of information




Travel Time
(minutes)
30
60
90
120
150
180
Adult Hematopoietic Cell Transplant (HCT) Services

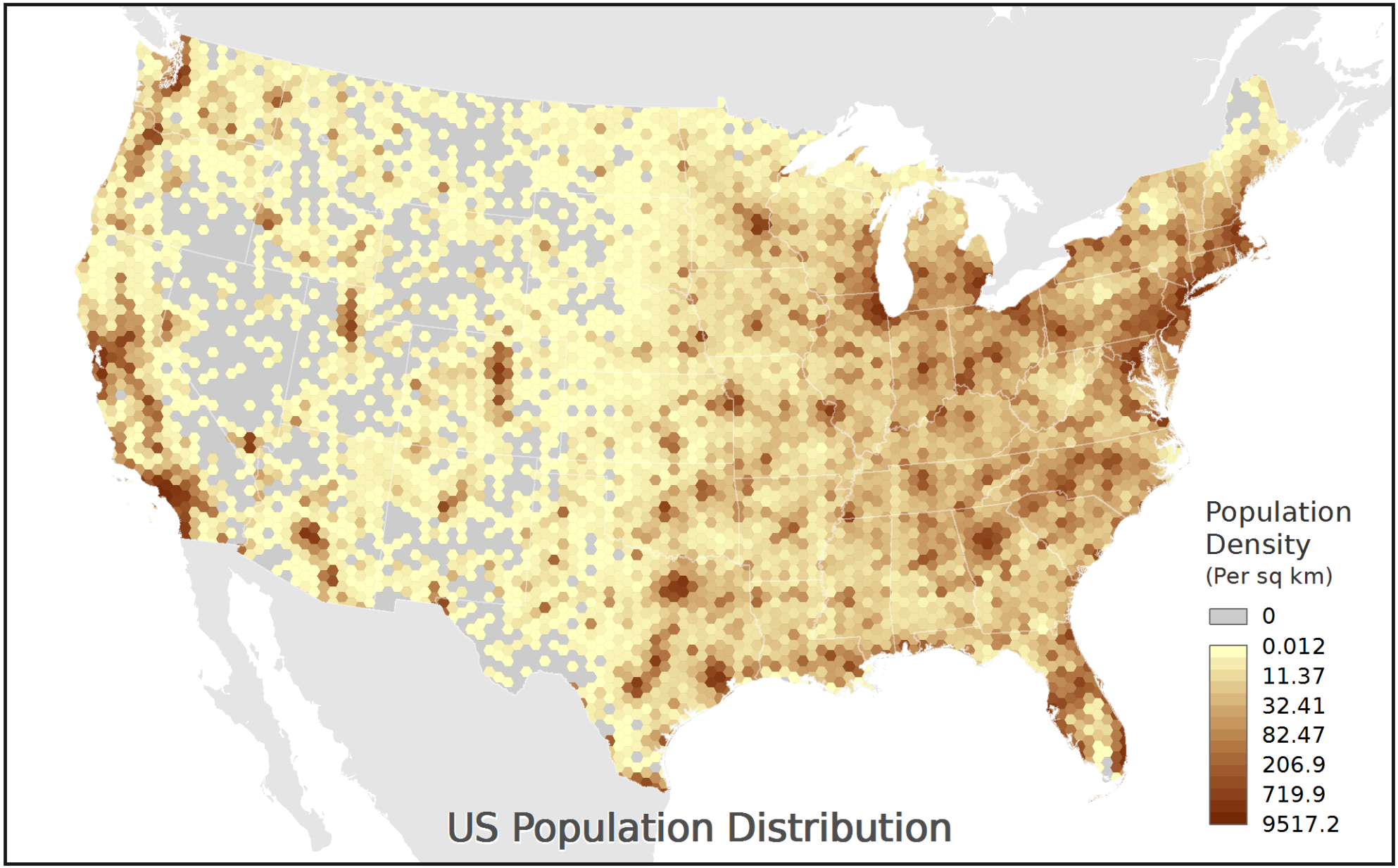

Population
Density
(Per sq km)
0
0.012
11.37
32.41
82.47
206.9
719.9
9517.2
US Population Distribution

Table 2: **Summary statistics for adult and pediatric access to HCT facilities in the conterminous US.** For the access columns, the figures are in percent of the total group population. AIAN is *American Indian or Alaska Native*, HWPI is *Native Hawaiian or Other Pacific Islander*, and Multiple is *Two or more races reported.*

	Population	30 min	60 min	90 min	120 min	150 min	180 min
US Population	306,675,006	46.7	65.9	77.1	85.3	90.6	93.9
Pediatric (0–17)	73,690,271	42.4	61.0	72.0	81.0	87.2	91.5
0–9	40,274,368	42.8	61.1	72.0	81.0	87.2	91.4
10–17	33,415,903	42.0	61.0	72.1	81.1	87.3	91.5
Male	37,692,718	42.4	61.0	72.0	81.0	87.2	91.4
Female	35,997,553	42.5	61.1	72.0	81.1	87.2	91.5
White	39,578,416	32.9	55.3	68.1	78.7	86.0	90.7
Black	10,352,121	55.4	68.3	78.1	86.7	93.7	96.9
Hispanic	17,070,811	52.3	66.8	75.1	81.7	85.4	89.6
AIAN	613,648	18.5	28.6	36.9	48.3	59.1	68.0
Asian	3,087,832	69.7	82.8	89.0	92.9	95.1	96.8
HWPI	95,339	50.5	67.6	78.3	83.6	86.2	88.3
Other	222,302	53.7	72.2	80.9	88.3	93.1	95.6
Multiple	2,669,802	43.3	62.7	74.1	82.9	88.7	92.3
All minorities	34,111,855	53.5	67.7	76.6	83.8	88.6	92.3
Adult (18+)	232,984,735	48.0	67.4	78.6	86.6	91.7	94.7
18–29	51,416,023	50.1	68.3	79.3	86.9	91.9	94.8
30–44	60,627,621	50.8	70.2	80.5	87.7	92.3	95.1
45–59	64,223,419	47.3	67.5	78.8	86.7	91.7	94.7
60–74	38,277,320	43.6	63.6	75.9	85.0	90.6	94.0
75+	18,440,352	44.4	63.7	76.1	85.4	91.0	94.2
Male	113,037,737	47.5	67.0	78.3	86.4	91.5	94.5
Female	119,946,998	48.5	67.8	78.9	86.9	91.8	94.8
White	156,474,473	41.1	63.2	76.3	85.6	91.3	94.5
Black	27,291,874	62.7	75.7	85.0	91.8	96.2	98.0
Hispanic	33,246,692	59.3	74.6	80.9	85.5	89.1	92.4
AIAN	1,528,071	27.4	41.4	52.8	63.4	72.8	78.7
Asian	10,826,539	75.7	88.7	92.6	95.0	96.4	97.7
HWPI	250,796	55.0	74.5	82.0	86.8	89.9	92.6
Other	378,964	67.5	82.8	88.3	91.9	94.8	96.5
Multiple	2,987,326	53.4	71.7	81.4	88.0	91.9	94.5
All minorities	76,510,262	62.0	76.2	83.5	88.8	92.5	95.0

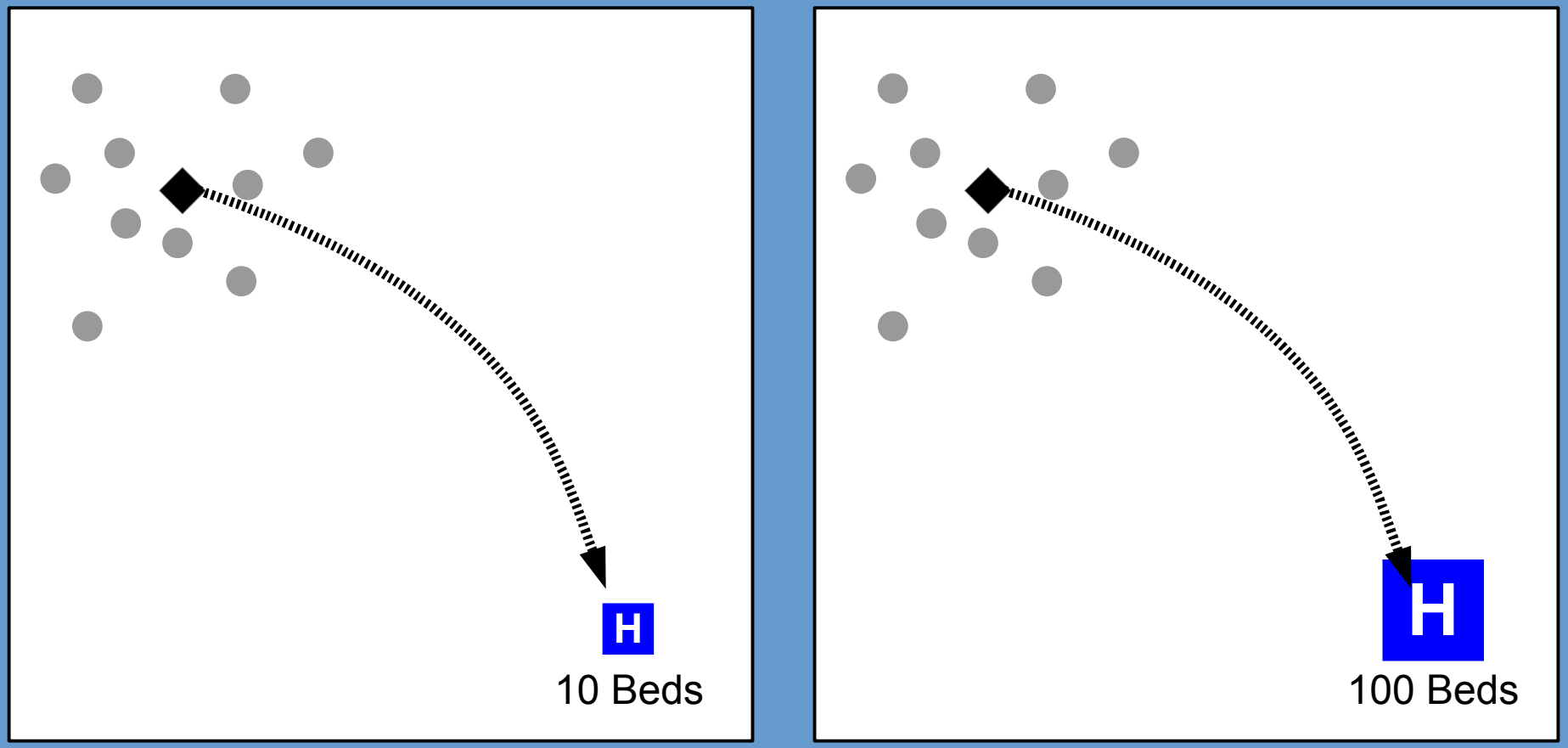
Accessibility

- Very simple dimension of access, but can be very powerful
  - Friction of distance as a barrier to use of services
  - Works well when all providers or facilities offer similar volume of services and quality of services

Accessibility

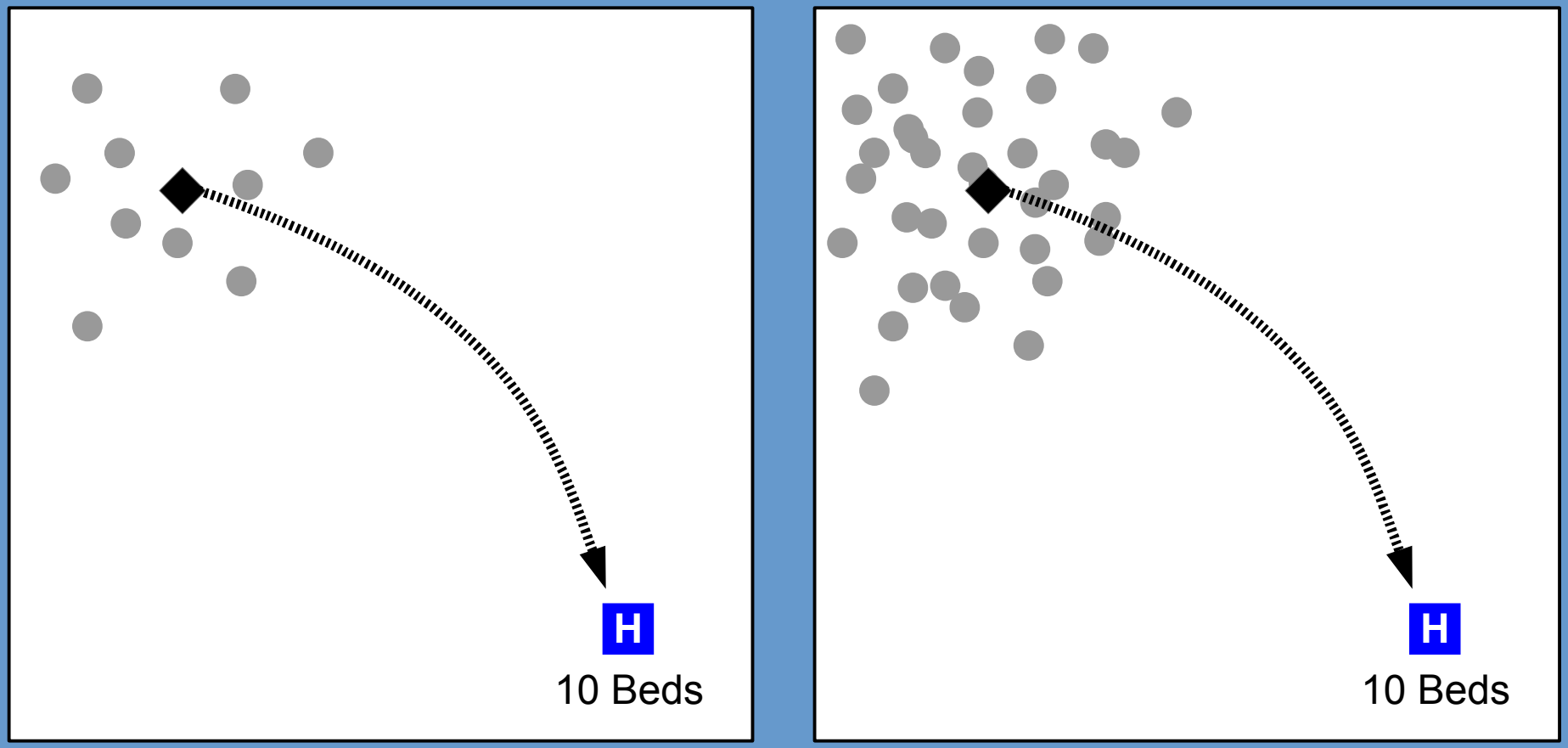
- Use with care...
  - Unable to capture differences in the volume of services and quality of services
    - Effects of distance may not be the same when considering these factors
    - In some cases, this is not a big deal... but in others, it should be considered
  - Unable to capture differences in the number of people that will use the services
    - Competition for limited resources

Accessibility



Which population (left or right) has better access?

Accessibility



Which population (left or right) has better access?

Availability

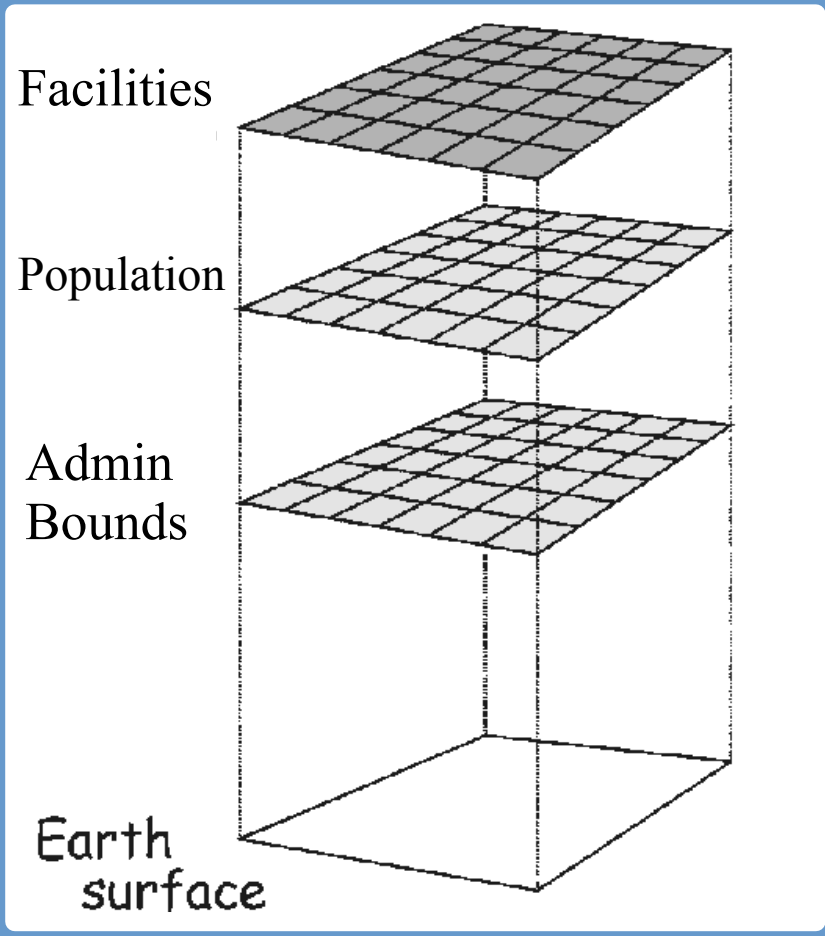
- Measure of the magnitude of services available to the population
  - Magnitude: how many or how much?
    - Easy examples are: the number of beds in a hospital or the number of physicians practicing at a clinic
    - Must be considered in relation to the number of people attempting to use the services

Availability

- Measure of the magnitude of services available to the population
  - To conduct a basic study of availability, you only need two inputs
    - Locations of people (aggregated to areal units, e.g., counties)
    - Locations of services (and measure of volume)

Availability

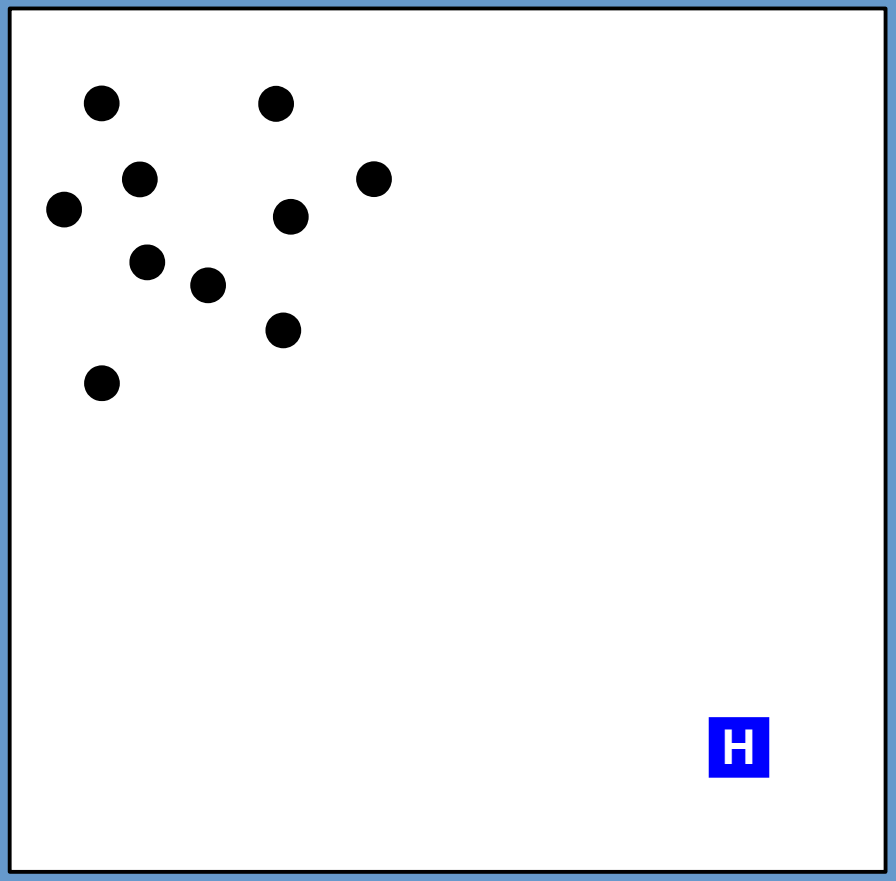
- Overlay
  - In the GIS, overlay the service locations with the population regions
    - Output regions have attributes of service locations falling inside regions



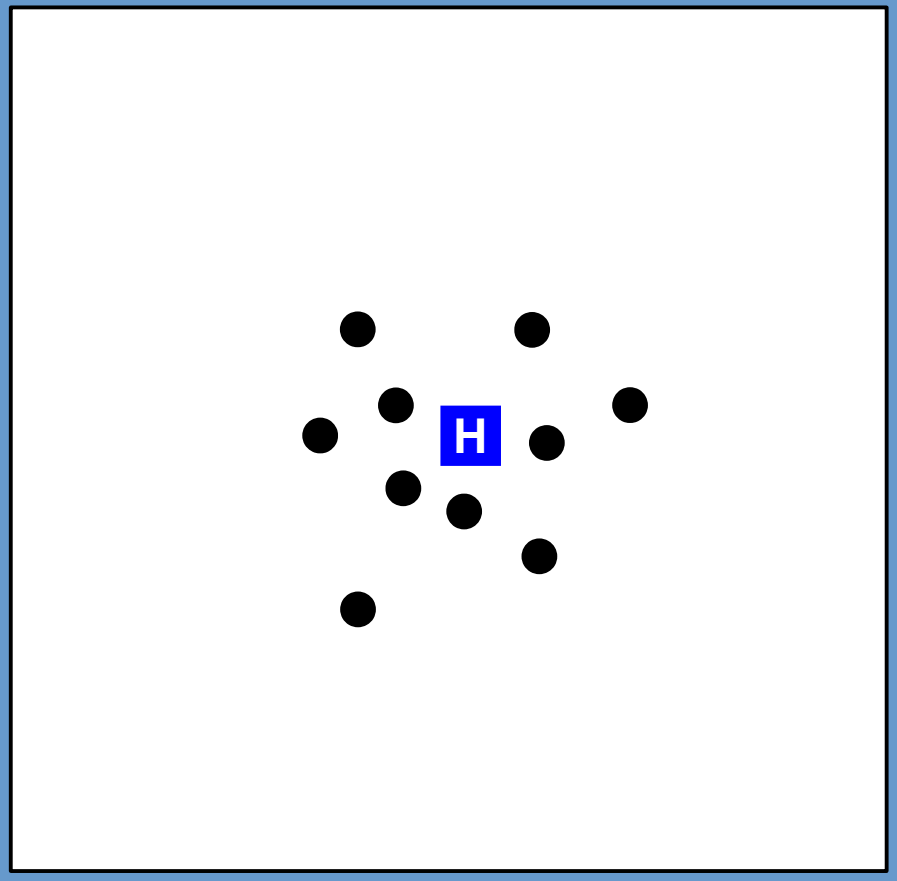
Availability

- Beware the supply / person ratio and container-based approaches
  - Considers accessibility, but only somewhat
    - Treats everyone within the geographic unit exactly the same
    - Does not consider ability to go outside of geographic unit
  - MAUP issue

Availability



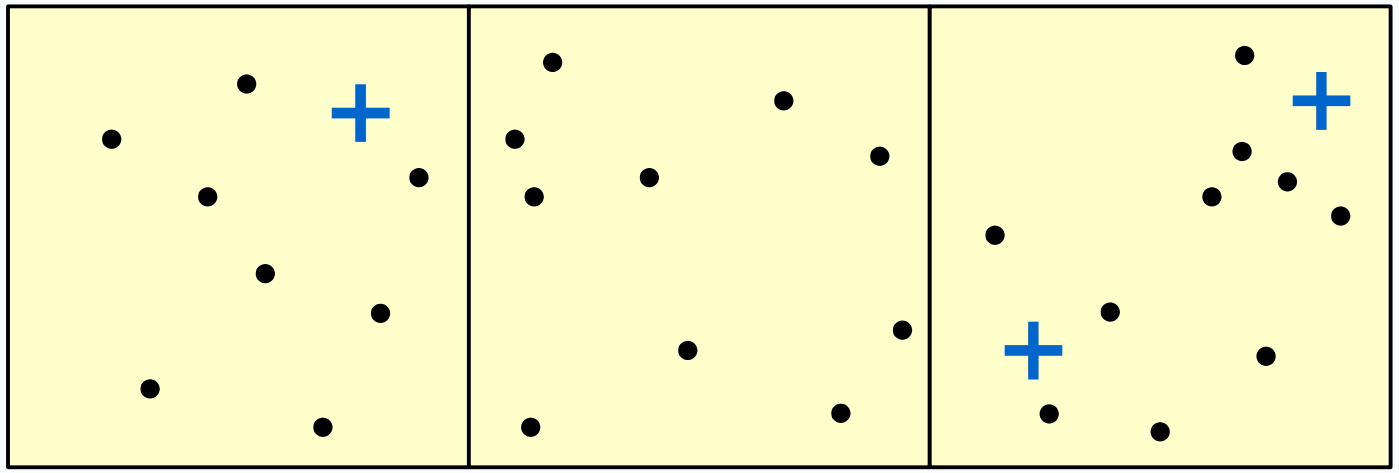
100 beds / 1000 people
= 0.1 beds per person



100 beds / 1000 people
= 0.1 beds per person

Availability

Container approach



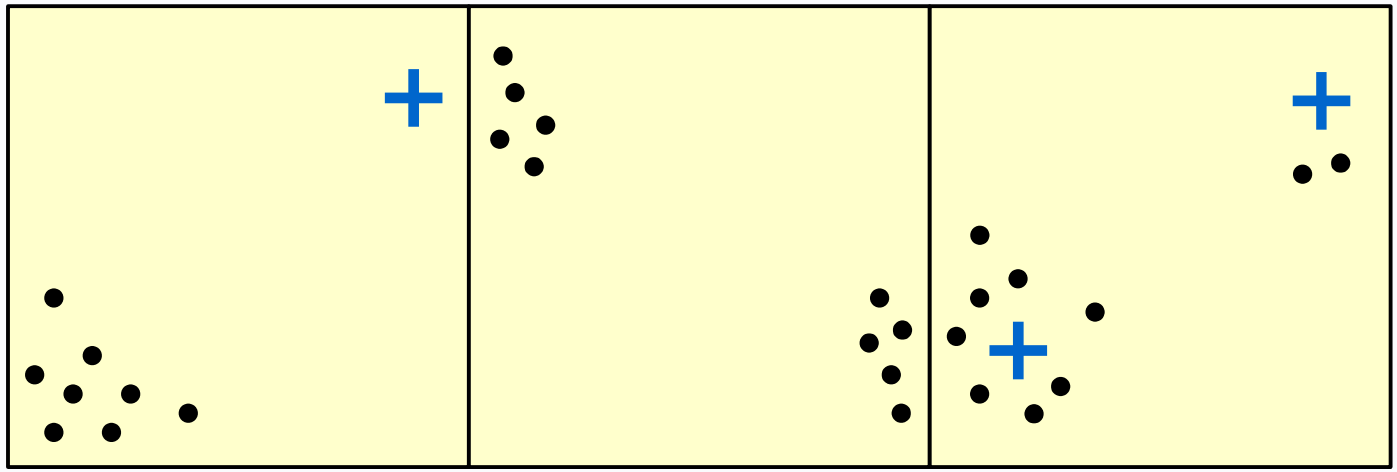
1 / 8
0.125
(facilities per person)

0 / 10
0
(facilities per person)

2 / 10
0.2
(facilities per person)

Availability

Container approach



1 / 8
0.125
(facilities per person)

0 / 10
0
(facilities per person)

2 / 10
0.2
(facilities per person)

Spatial Accessibility

- Merges measures of accessibility and availability
  - Based on a Gravity Model (Newton, not Einstein)
    - Forces pulling people toward facilities
      - Attractive force conceptualized as potential spatial accessibility
  - Floating Catchment Area (FCA) metrics
    - Simultaneously incorporates distance, supply, and potential demand

Affordability

- Attempts capture the role that costs play in people's ability to use health care services
  - Facility / system perspective
    - How expensive is the service... or how is it paid for?
  - Population perspective
    - Does the population have resources to use the service?

Affordability

- Like accessibility, how affordability is integrated is highly dependent upon the health care system of a country/region
  - In the US, I use percent of the population with health insurance to capture this dimension of access
  - How about in other places?
    - Might not be important!

Acceptability

- Attempts to capture how well the type of services coincide with the population's preferences or beliefs
  - This can be a bit difficult to capture for populations
    - Consider those that prefer non-traditional services
    - Consider differing religious beliefs regarding health care use

Acceptability

- Can be highly important in some countries and regions
  - e.g., if there are a number of people that would rather not use traditional health care services
  - Can be highly important when studying a particular population group

Accommodation

- Considers whether the services are provided/organized in a way that allows the patients to use them
  - Again, this can be a bit difficult to capture for populations
  - Service characteristics
    - Hours of operation
      - e.g., services are only available during business hours for someone that cannot take time off of work
    - Languages spoken

Access to Health Care

- Why is access to care difficult to operationalize?
  - How do you measure potential?
    - Accessibility example…
    - We know that Person 1 who lives 5 miles from a doctor has better accessibility than Person 2 who lives 25 miles from a doctor
      - How much less "potential" accessibility does Person 2 have? 20 miles? Is miles a measure of access?

Access to Health Care

- Why is access to care difficult to operationalize?
  - How do you compare the importance of each of the dimensions?
    - Consider if we had perfect measurements of each of the five dimensions of access...
    - How would be weight them when attempting to combine them?
      - e.g., is accessibility more important than affordability or accommodation?

Access to Health Care

- GIS and Public Health studies
  - Often emphasize accessibility and availability (and sometimes affordability)
  - Not always the case though!
    - These are simply the dimensions that are most easily quantifiable for large groups of people

Keywords

- Interactions
- Formal care
- Health Care Systems
- Service types
  - Primary, secondary, tertiary
- Utilization
- Access to health care
  - Accessibility
  - Availability
  - Affordability
  - Acceptability
  - Accommodation

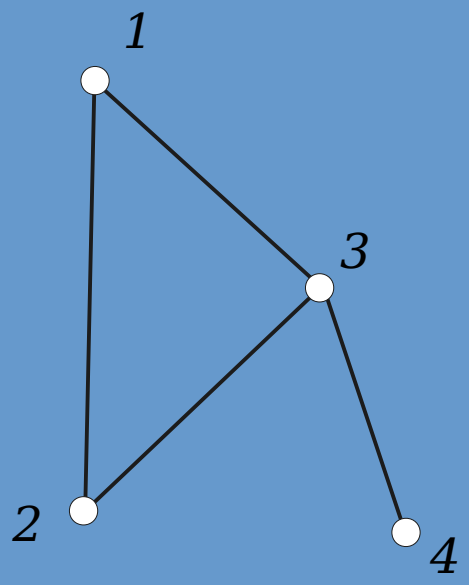
Network Analysis

Outline

- Networks
- Network datasets
- Distance
- Service Areas
- Testing a network dataset

What is a Network?

- System of connected lines and points
  - In a GIS, geometry is similar to vector data
  - Connectivity is the key concept
  - Space is undefined off of the network



Connectivity matrix

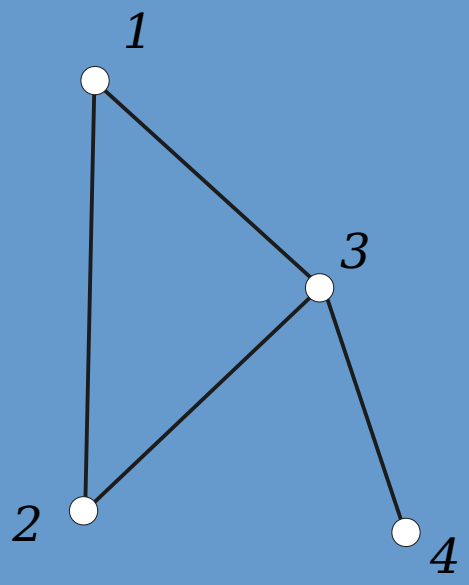
	1	2	3	4
1		x	x	
2	x		x	
3	x	x		x
4			x	

Distance matrix

	1	2	3	4
1		3	2	
2	3		2	
3	2	2		2
4			2	

What is a Network?

- System of connected lines and points
  - Networks in GIS are powerful because the network components are linked back to georeferenced positions



Connectivity matrix

	1	2	3	4
1		x	x	
2	x		x	
3	x	x		x
4			x	

Distance matrix

	1	2	3	4
1		3	2	
2	3		2	
3	2	2		2
4			2	

Networks and Geography

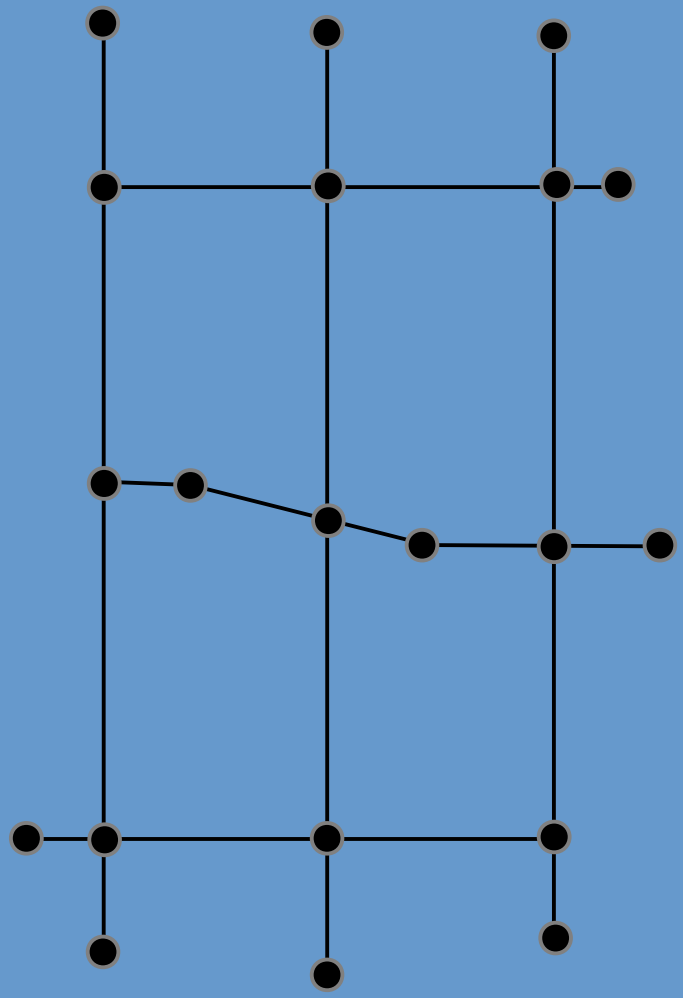
- Thinking about distance and movement through space
  - In many cases, human movement is constrained to a network or network-like features, e.g., a road network
    - Thus, true "separation" among places should not be measured as straight lines (Euclidean distances), as this is not how people "experience" distance!

Examples of Networks

- Water lines
- Sewer system
- Electricity grid
- Internet
- Social connections
- Road system
- Train system
- Phone system
- Hydrological system

Network Components

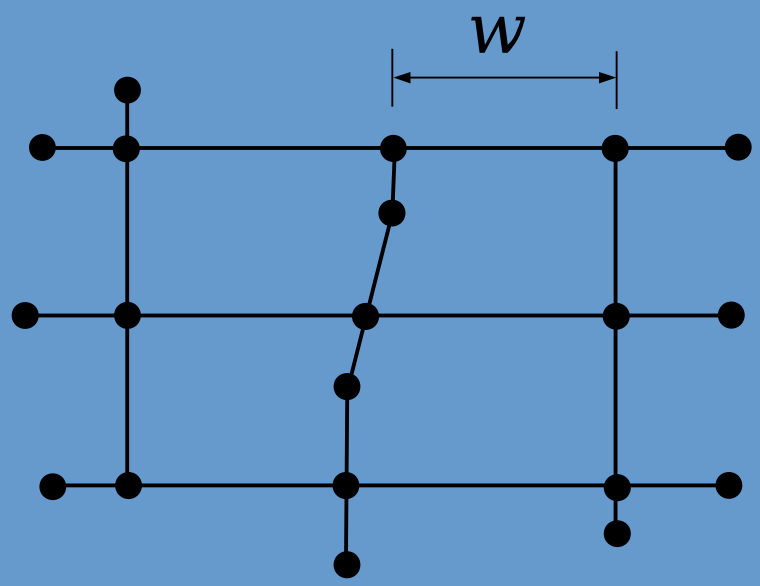
- Junctions
  - Point features
    - Define connections among edges
    - e.g., stream confluence, street intersection
- Edges
  - Line features
    - Connections among junctions on the network
    - e.g., stream segments, street segments



Network Attributes

- Weights
  - A weight can be assigned as the cost of traversing an element in the network
    - e.g., travel time or travel distance
    - Can be assigned/defined based on attributes of input data
    - Assigned to junctions and edges

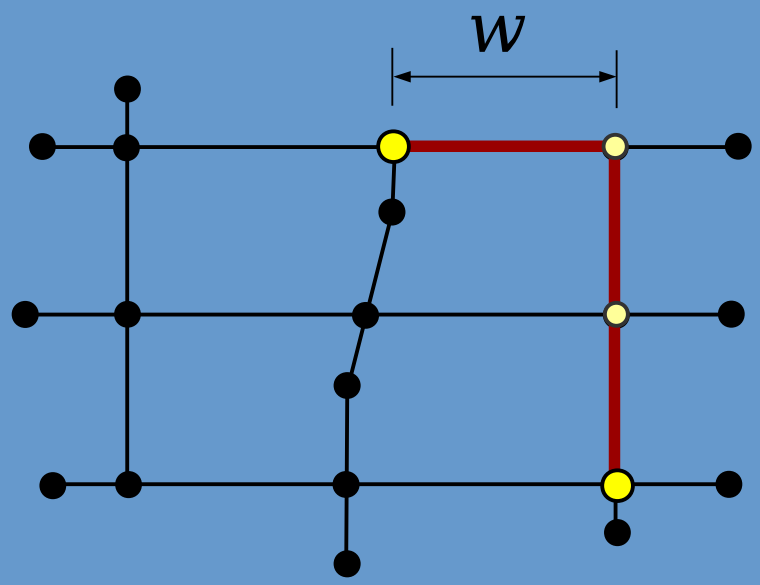
$$d = rate * time$$
$$time = d / rate$$



Network Attributes

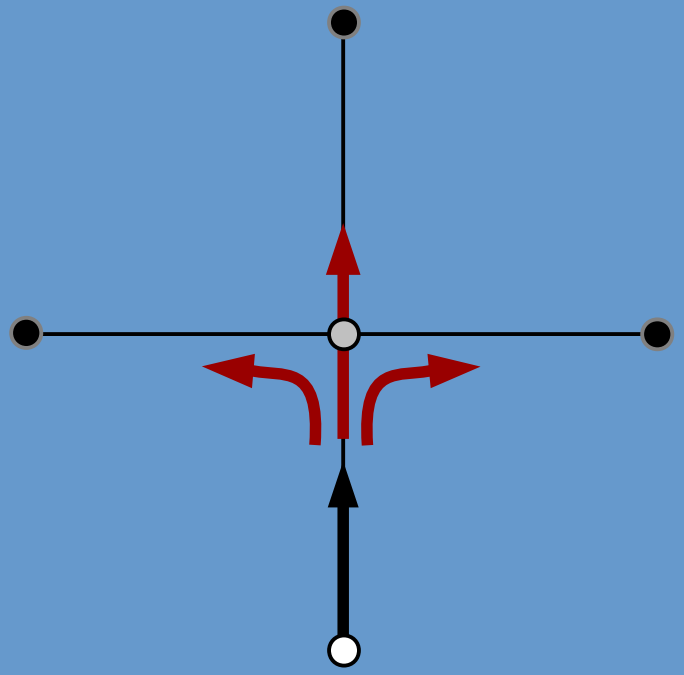
- Weights
  - A weight can be assigned as the cost of traversing an element in the network
    - e.g., travel time or travel distance
    - Can be assigned/defined based on attributes of input data
    - Assigned to junctions and edges

$$d = rate * time$$
$$time = d / rate$$



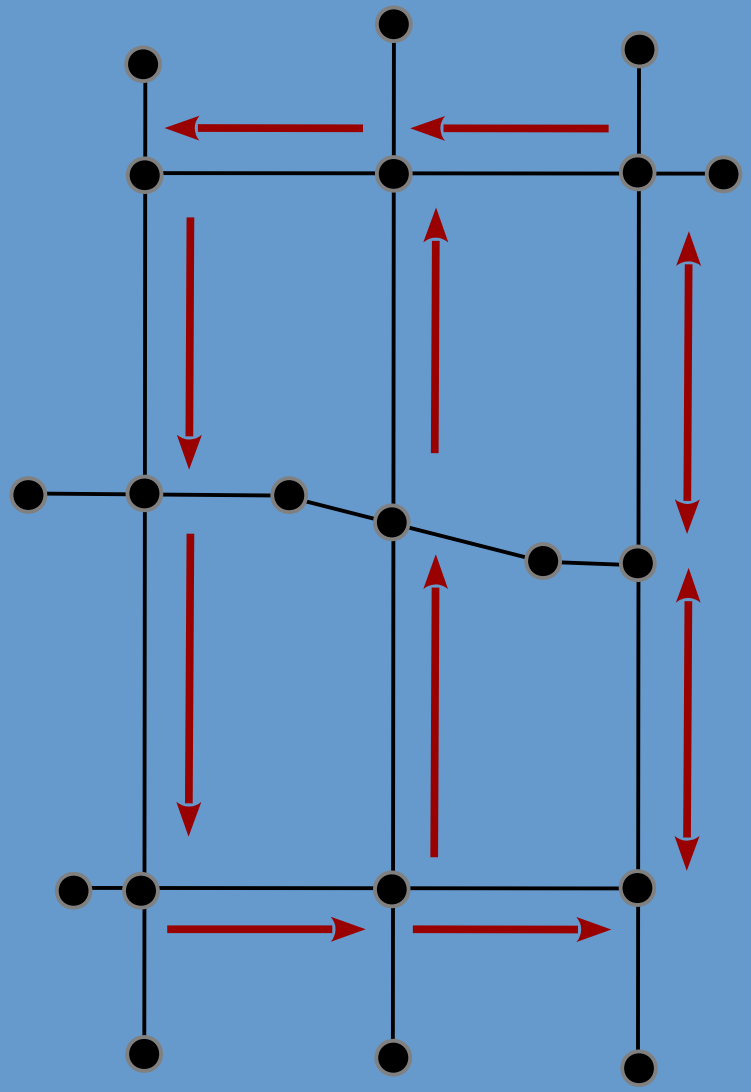
Network Attributes

- Turns
  - Weights assigned for making a directional "change" at a junction
  - Can be assigned locally or globally
    - Global turns (all junctions)
      - Based on the "direction" of the turn
      - For road networks, can be used to simulate driving conditions
    - Local turns (defined separately for each junction)



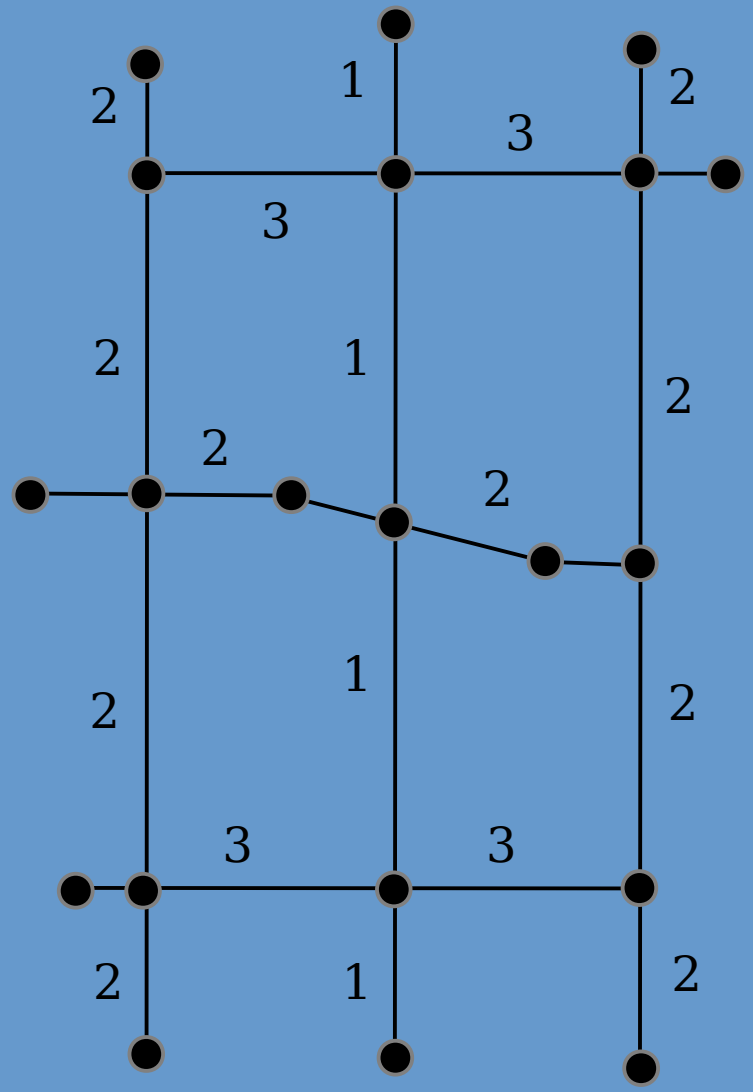
Network Attributes

- Direction
  - The directionality (from and to junction) can be defined as an attribute of an edge
  - e.g., stream networks and one-way streets



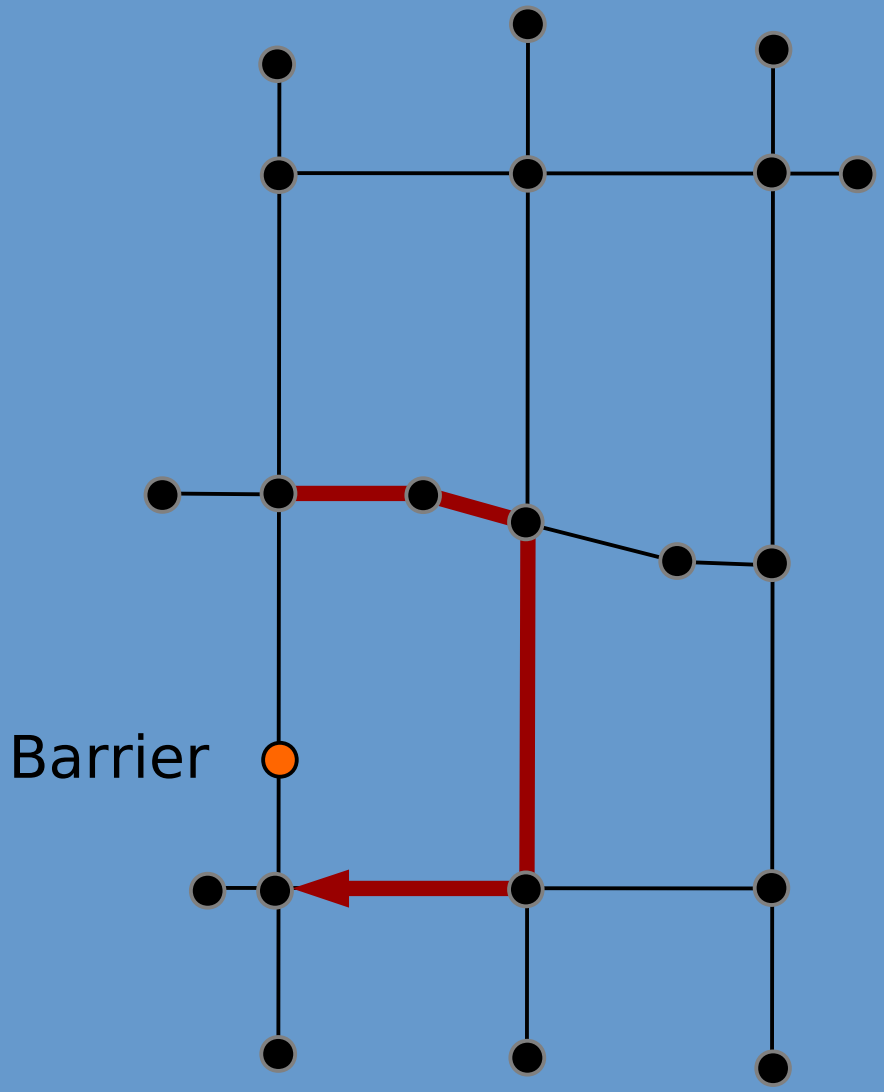
Network Attributes

- Hierarchy
  - An attribute of edges that describes the relative importance of that edge
  - Generally, used in routing applications to encourage travel on major roads



Network Attributes

- Barriers (point)
  - A special type of junction or an attribute of junction that restricts movement

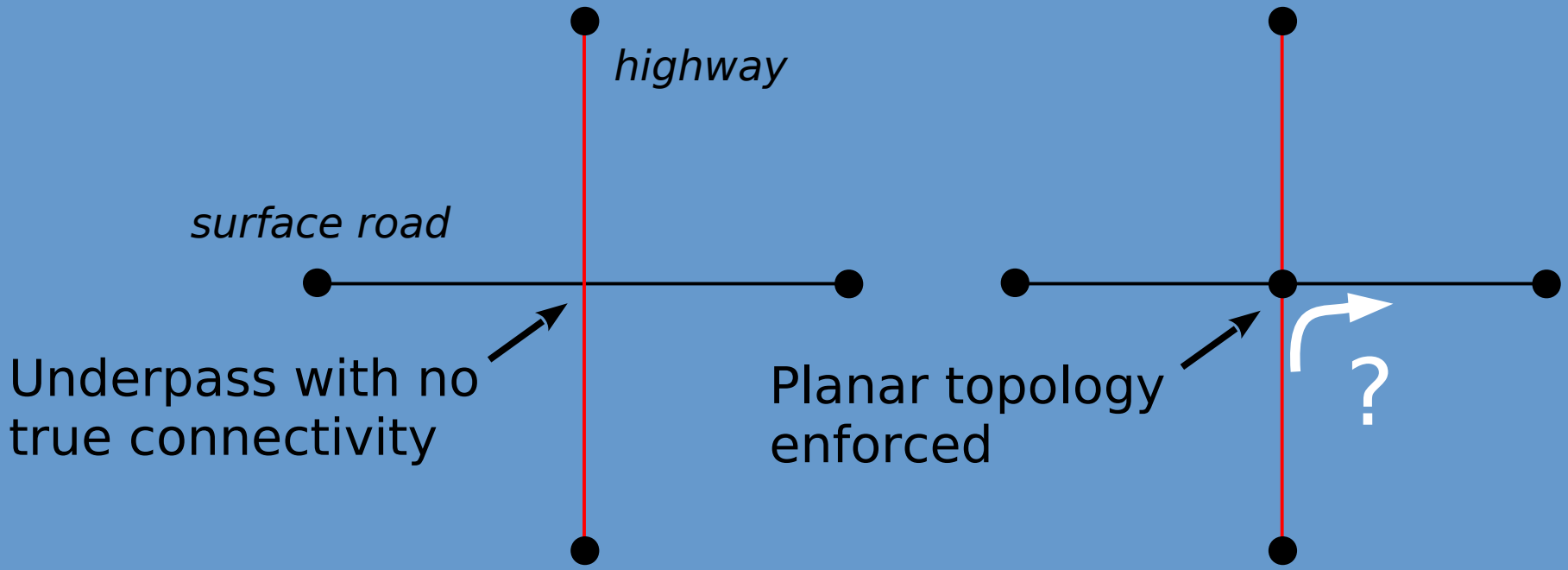


Network Dataset

- Junctions and edges are the "base" of the network dataset
  - Attributes and additional information
    - Connectivity (e.g., under- or overpass for roads)
    - Weights
    - Turn penalties
    - Direction
    - Hierarchy
    - Barriers
    - Street name and address range
      - For geocoding and directions/routing

Network Connectivity

- Defining connectivity is extremely important for "road" networks in a GIS
  - However, this can be at odds with planar topology!

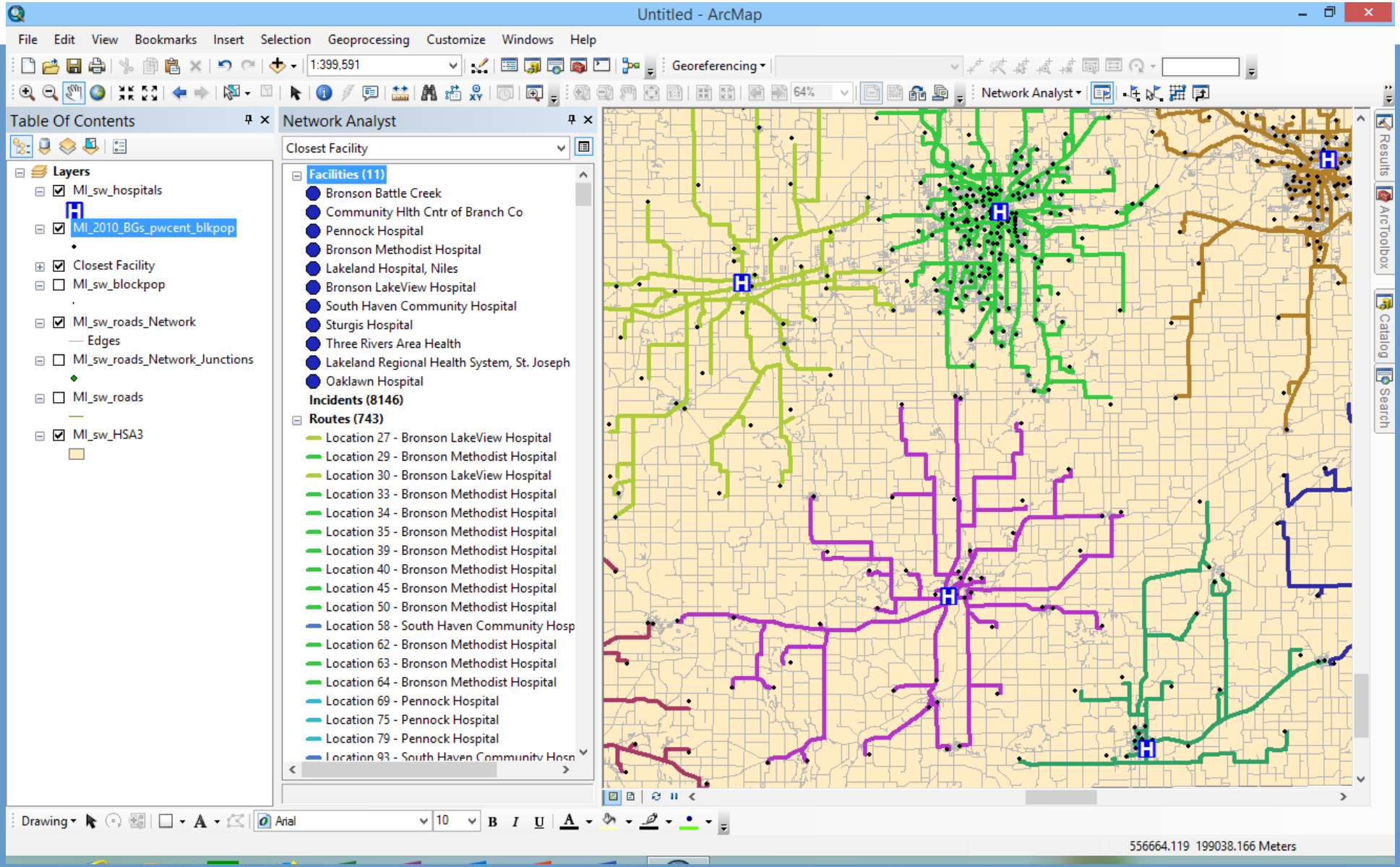


Network Operations

- Particularly useful for health-related studies
  - Distance measurement
    - Shortest path
    - Origin-Destination (OD) matrix
  - Service areas
  - Location / Allocation
    - Where to site new facility

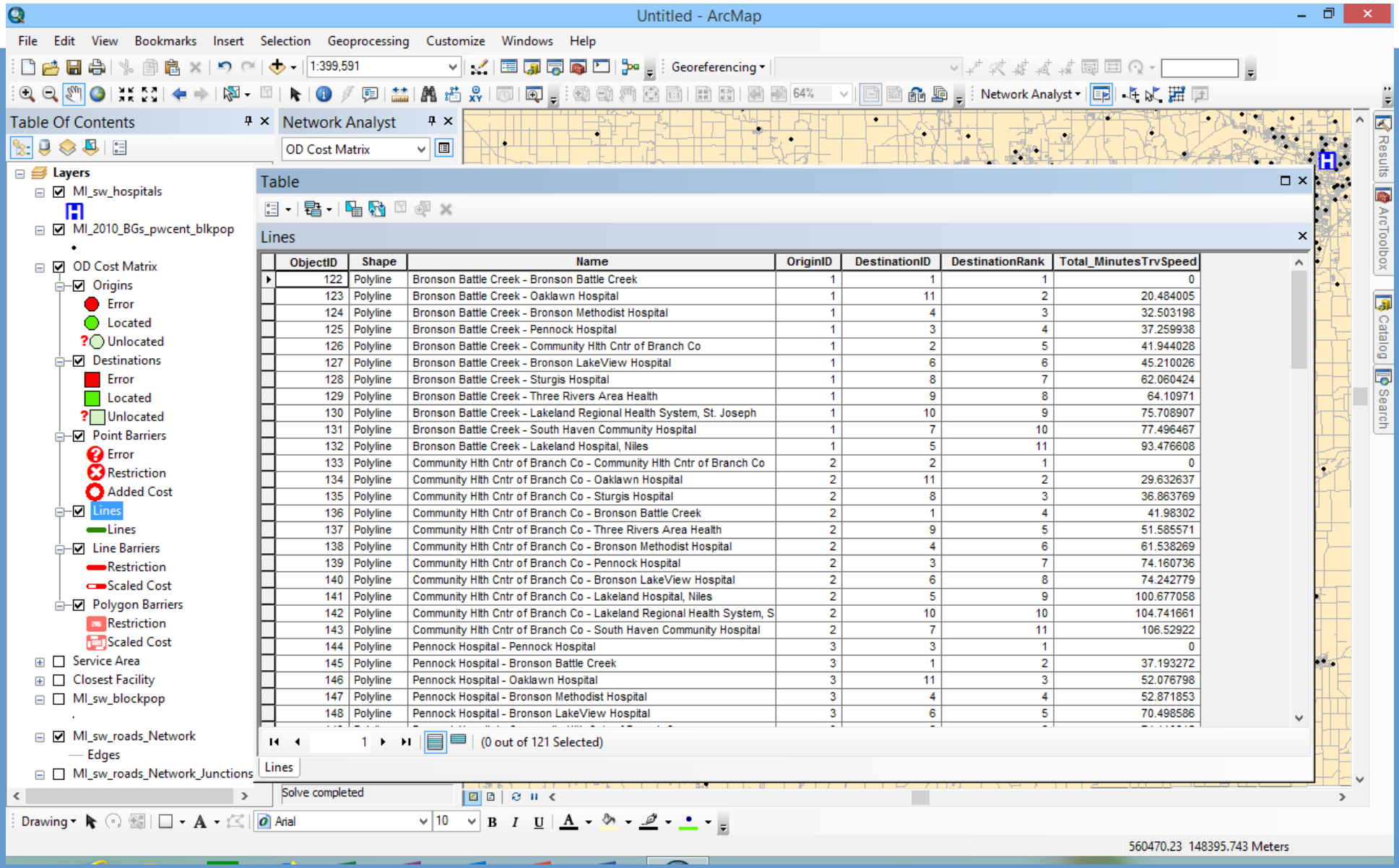
Distance Measurement

- What is the shortest distance between points, given network connectivity?
  - Start / End locations
  - Start / End locations plus additional points (also called stops) in a specific order
- Distance can be defined as:
  - The summed length of edges, travel distance
  - The summed weight of edges/junctions (plus turns, if applicable), travel time


Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:399,591
Georeferencing
64%
Network Analyst
Table Of Contents
Layers
MI_sw_hospitals
MI_2010_BGs_pwcent_blkpop
Closest Facility
MI_sw_blockpop
MI_sw_roads_Network
Edges
MI_sw_roads_Network_Junctions
MI_sw_roads
MI_sw_HSA3
Network Analyst
Closest Facility
Facilities (11)
Bronson Battle Creek
Community Hlth Cntr of Branch Co
Pennock Hospital
Bronson Methodist Hospital
Lakeland Hospital, Niles
Bronson LakeView Hospital
South Haven Community Hospital
Sturgis Hospital
Three Rivers Area Health
Lakeland Regional Health System, St. Joseph
Oaklawn Hospital
Incidents (8146)
Routes (743)
Location 27 - Bronson LakeView Hospital
Location 29 - Bronson Methodist Hospital
Location 30 - Bronson LakeView Hospital
Location 33 - Bronson Methodist Hospital
Location 34 - Bronson Methodist Hospital
Location 35 - Bronson Methodist Hospital
Location 39 - Bronson Methodist Hospital
Location 40 - Bronson Methodist Hospital
Location 45 - Bronson Methodist Hospital
Location 50 - Bronson Methodist Hospital
Location 58 - South Haven Community Hosp
Location 62 - Bronson Methodist Hospital
Location 63 - Bronson Methodist Hospital
Location 64 - Bronson Methodist Hospital
Location 69 - Pennock Hospital
Location 75 - Pennock Hospital
Location 79 - Pennock Hospital
Results
ArcToolbox
Catalog
Search
Drawing
Arial
10
556664.119 199038.166 Meters

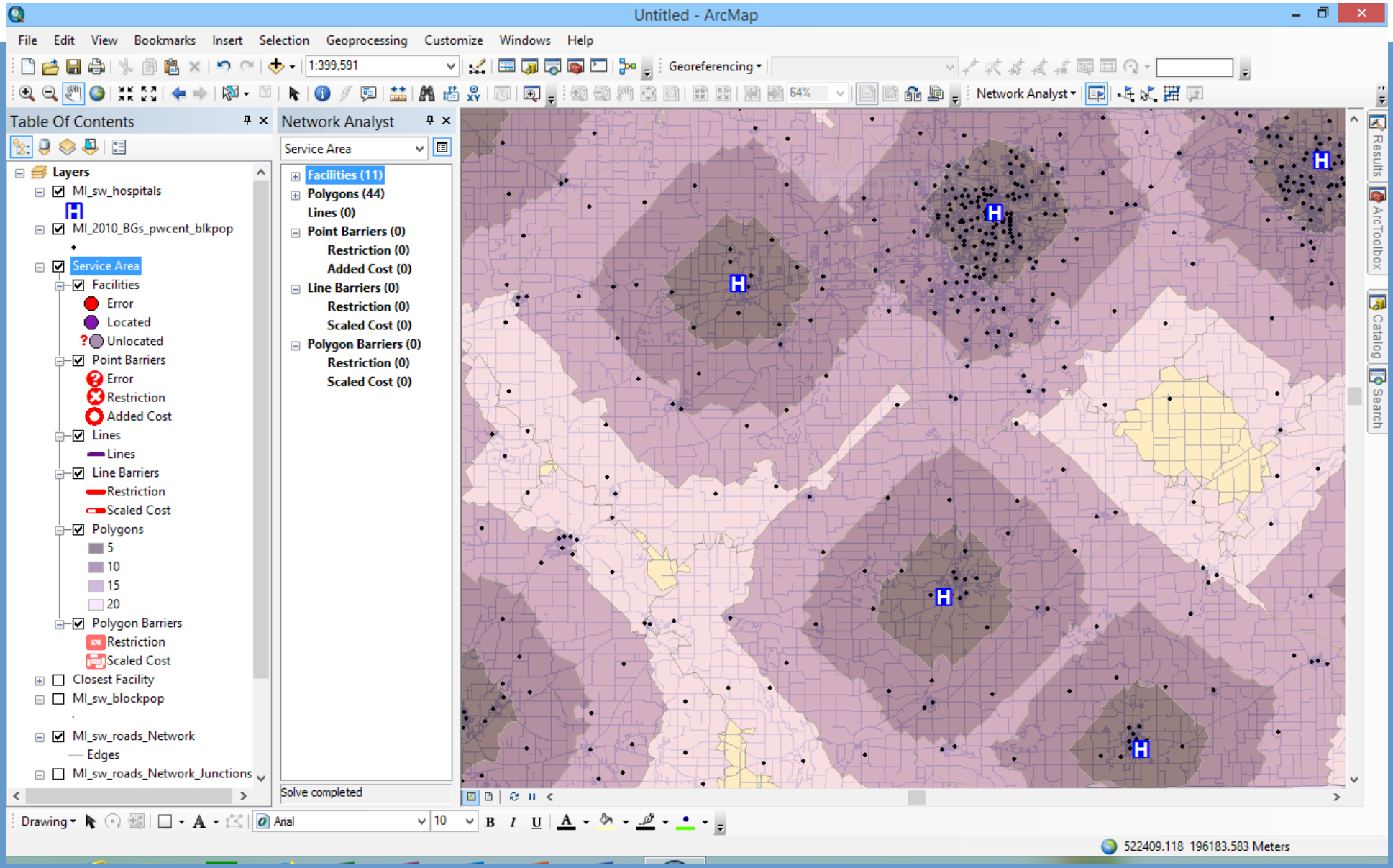
Distance Measurement

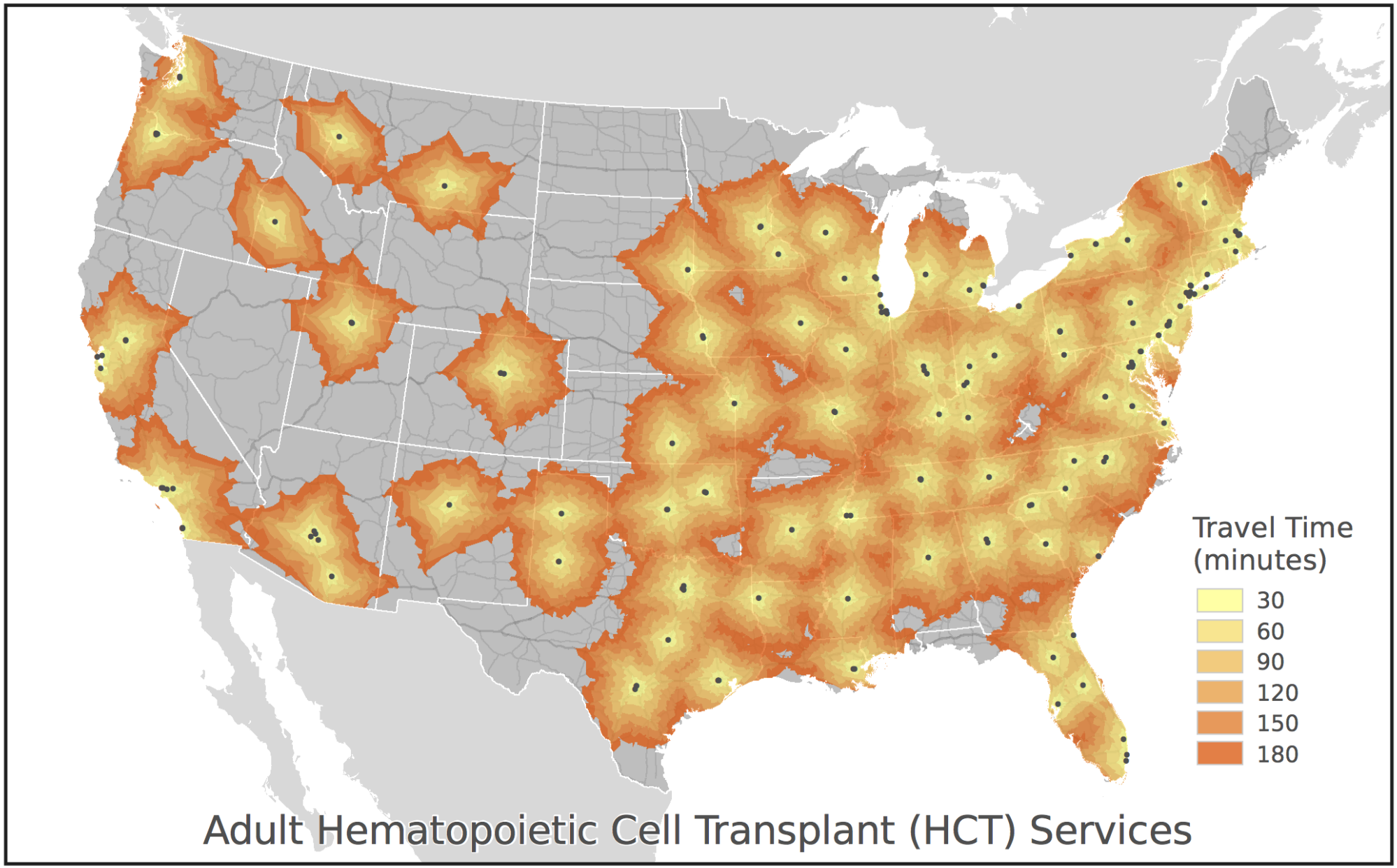
- Origin-Destination (OD) matrix
  - Shortest distance between multiple origins (*n*) and multiple destinations (*m*)
    - An *n* x *m* matrix
    - But, in reality, a long table

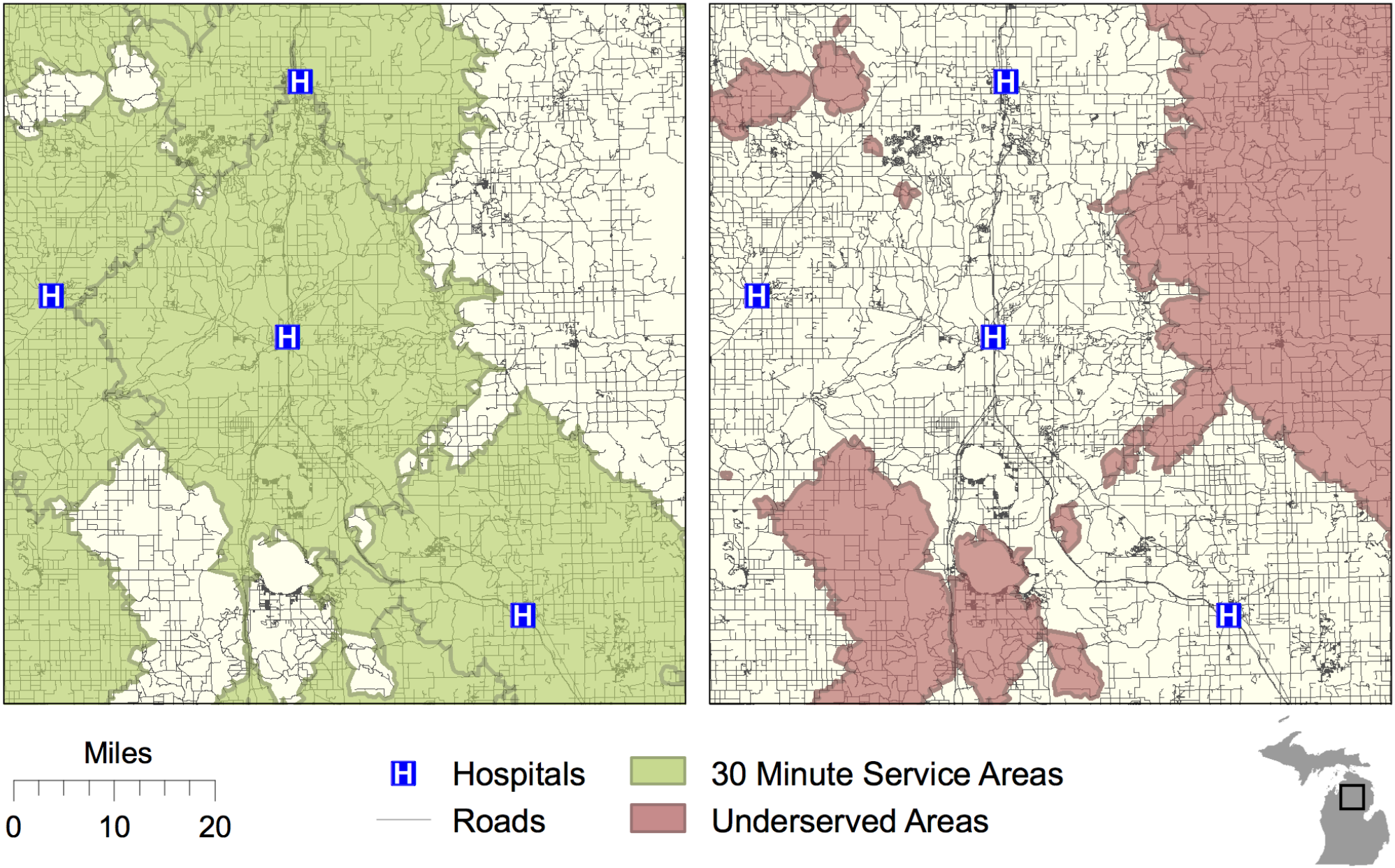

Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:399,591
Georeferencing
Network Analyst
Table Of Contents
Layers
MI_sw_hospitals
MI_2010_BGs_pwcent_blkpop
OD Cost Matrix
Origins
Error
Located
Unlocated
Destinations
Error
Located
Unlocated
Point Barriers
Error
Restriction
Added Cost
Lines
Lines
Line Barriers
Restriction
Scaled Cost
Polygon Barriers
Restriction
Scaled Cost
Service Area
Closest Facility
MI_sw_blockpop
MI_sw_roads_Network
Edges
MI_sw_roads_Network_Junctions
Network Analyst
OD Cost Matrix
Table
Lines
ObjectID Shape Name OriginID DestinationID DestinationRank Total_MinutesTrvSpeed
122 Polyline Bronson Battle Creek - Bronson Battle Creek 1 1 1 0
123 Polyline Bronson Battle Creek - Oaklawn Hospital 1 11 2 20.484005
124 Polyline Bronson Battle Creek - Bronson Methodist Hospital 1 4 3 32.503198
125 Polyline Bronson Battle Creek - Pennock Hospital 1 3 4 37.259938
126 Polyline Bronson Battle Creek - Community Hlth Cntr of Branch Co 1 2 5 41.944028
127 Polyline Bronson Battle Creek - Bronson LakeView Hospital 1 6 6 45.210026
128 Polyline Bronson Battle Creek - Sturgis Hospital 1 8 7 62.060424
129 Polyline Bronson Battle Creek - Three Rivers Area Health 1 9 8 64.10971
130 Polyline Bronson Battle Creek - Lakeland Regional Health System, St. Joseph 1 10 9 75.708907
131 Polyline Bronson Battle Creek - South Haven Community Hospital 1 7 10 77.496467
132 Polyline Bronson Battle Creek - Lakeland Hospital, Niles 1 5 11 93.476608
133 Polyline Community Hlth Cntr of Branch Co - Community Hlth Cntr of Branch Co 2 2 1 0
134 Polyline Community Hlth Cntr of Branch Co - Oaklawn Hospital 2 11 2 29.632637
135 Polyline Community Hlth Cntr of Branch Co - Sturgis Hospital 2 8 3 36.863769
136 Polyline Community Hlth Cntr of Branch Co - Bronson Battle Creek 2 1 4 41.98302
137 Polyline Community Hlth Cntr of Branch Co - Three Rivers Area Health 2 9 5 51.585571
138 Polyline Community Hlth Cntr of Branch Co - Bronson Methodist Hospital 2 4 6 61.538269
139 Polyline Community Hlth Cntr of Branch Co - Pennock Hospital 2 3 7 74.160736
140 Polyline Community Hlth Cntr of Branch Co - Bronson LakeView Hospital 2 6 8 74.242779
141 Polyline Community Hlth Cntr of Branch Co - Lakeland Hospital, Niles 2 5 9 100.677058
142 Polyline Community Hlth Cntr of Branch Co - Lakeland Regional Health System, S 2 10 10 104.741661
143 Polyline Community Hlth Cntr of Branch Co - South Haven Community Hospital 2 7 11 106.52922
144 Polyline Pennock Hospital - Pennock Hospital 3 3 1 0
145 Polyline Pennock Hospital - Bronson Battle Creek 3 1 2 37.193272
146 Polyline Pennock Hospital - Oaklawn Hospital 3 11 3 52.076798
147 Polyline Pennock Hospital - Bronson Methodist Hospital 3 4 4 52.871853
148 Polyline Pennock Hospital - Bronson LakeView Hospital 3 6 5 70.498586
1 (0 out of 121 Selected)
Lines
Solve completed
Drawing
Arial
10
560470.23 148395.743 Meters
Results
ArcToolbox
Catalog
Search

Service Area

- Given a network, the goal is to find all locations serviced by a single location on the network, within a certain distance or time
  - Output is polygon
- How it works
  - Trace all routes to specified distance/time
  - Mark "endpoint" along all edges
  - Create polygon
    - Multiple options


Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:399,591
Georeferencing
Network Analyst
Table Of Contents
Layers
MI_sw_hospitals
MI_2010_BGs_pwcent_blkpop
Service Area
Facilities
Error
Located
Unlocated
Point Barriers
Error
Restriction
Added Cost
Lines
Lines
Line Barriers
Restriction
Scaled Cost
Polygons
5
10
15
20
Polygon Barriers
Restriction
Scaled Cost
Closest Facility
MI_sw_blockpop
MI_sw_roads_Network
Edges
MI_sw_roads_Network_Junctions
Network Analyst
Service Area
Facilities (11)
Polygons (44)
Lines (0)
Point Barriers (0)
Restriction (0)
Added Cost (0)
Line Barriers (0)
Restriction (0)
Scaled Cost (0)
Polygon Barriers (0)
Restriction (0)
Scaled Cost (0)
Solve completed
Results
ArcToolbox
Catalog
Search
Drawing
Arial
10
522409.118 196183.583 Meters


Travel Time
(minutes)
30
60
90
120
150
180
Adult Hematopoietic Cell Transplant (HCT) Services


H
H
H
H
H
H
H
H
Miles
0
10
20
Hospitals
Roads
30 Minute Service Areas
Underserved Areas

Using ESRI's Road Network

- ESRI provides an online platform to conduct network analysis
  - Requires an ArcGIS account through UNC
  - Global coverage (varies by region)
  - Tool-based or API-based
    - Located in the Catalog area in ArcGIS
    - Ready-To-Use Services | Logistics
  - Basic steps
    - Load data in Table of Contents
    - Open tool and choose desired settings
    - Wait for data to return, write to new file

Using OpenSource Data

- Openroute Service
  - Uses OpenStreet Map services
  - Global coverage, crowdsourced
  - Tool-based or API-based
    - ORSTools plugin in QGIS (tutorial here!)
  - Can be used with QGIS network analysis
    - QGIS Network Analysis Plugin (tutorial here!)

Creating a Network Dataset

- For basic operations in a GIS, e.g., travel along roads
  - Requires an roads layer (vector)
  - Converted to network format by GIS
    - Most basic requirement: the layer must have a length attribute!
      - i.e., all line features have a defined length
    - Other attributes
      - For travel time, must have a speed limit attribute
      - For geocoding and routing, must have street name and address ranges (and directionality!!) - connectivity must be correctly defined

Testing a Network Dataset

- Using your own network dataset
  - How do travel estimates from your network compare to other travel estimates?
    - Or, how can you add parameters to your network to make it more "realistic"
      - e.g., traffic control
  - For example, the roads network I used in my dissertation work!
    - Original roads data did not have speed limit information
    - Compared numerous parameter settings in my network vs Google Maps

Table 1 Travel speeds (miles per hour, mph) used in custom-built network datasets

Road type	N1	N2	N3	N4	N5
Expressways	70	60	60	62	65
Ramps	25	25	25	25	20
City owned, major	35	30	30	35	30
City owned, minor	25	20	20	25	20
Private	25	25	25	25	20
Minor collectors	55	55	55	45	50
Rural arterials and major collectors	55	55	55	45	50
Rural local	45	45	45	45	40
Urban, state owned arterials and major collectors	35	35	35	35	30
Urban, county owned arterials and major collectors	45	45	45	45	40
Urban, state owned local	35	35	35	35	30
Urban, county primary local	55	55	55	45	50
Urban, county local	25	25	25	25	20

Table 2 Turn delays (seconds) used in custom-built network datasets

Turn type	N1	N2	N3	N4	N5
Non-existent expressway turn	1,200	1,200	1,200	1,200	1,200
Reverse (non U-turn)	8	8	10	45	20
Left	4	5	8	30	8
Right	2	3	5	15	5
Straight (with crossroad)	1	0	2	1	1
Straight (no crossroad)	0	0	0	0	0

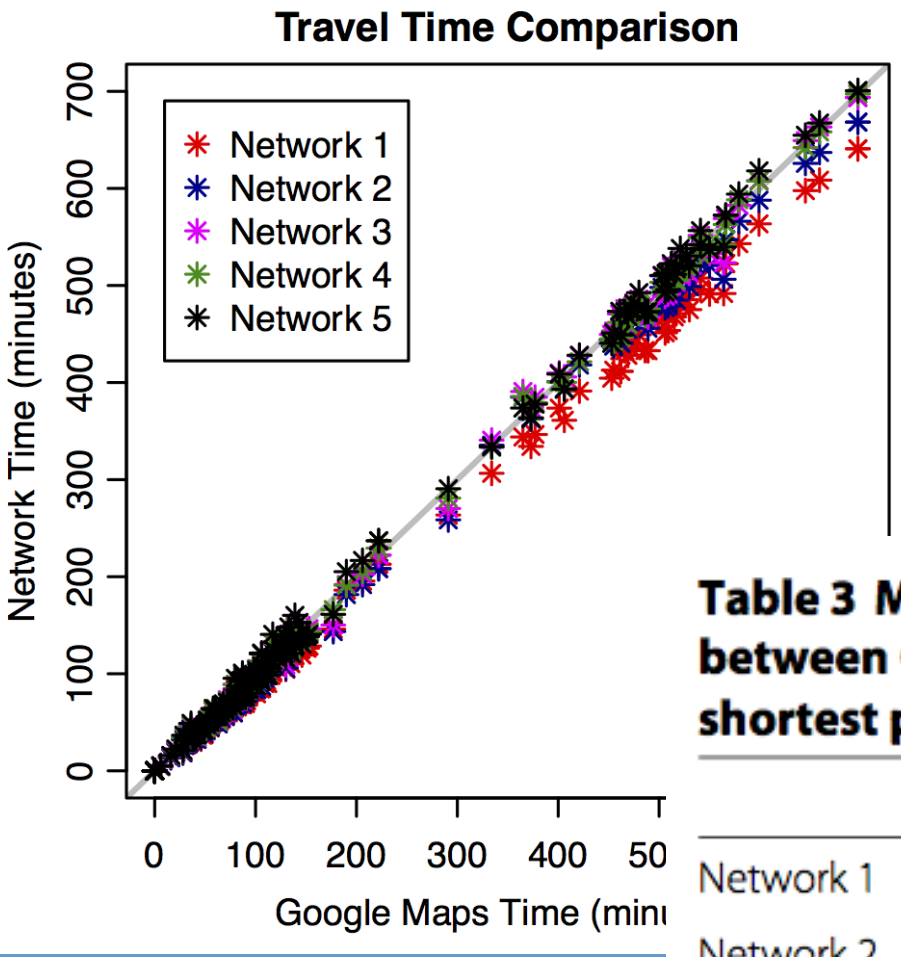


Table 3 Mean difference in travel time and road distance between Google Maps and custom-built networks in shortest path analysis

	Time (minutes)	Distance (miles)
Network 1	18.39	2.84
Network 2	8.29	6.41
Network 3	1.54	4.42
Network 4	2.33	3.04
Network 5	0.87	2.55

Keywords

- Networks
- Junctions and edges
- Attributes
  - Weights, Turns, Direction, Hierarchy
- Operations
  - Distance measurement, Service areas, Location / Allocation