Geography and GIS I

Lecture #2 | GEOG 510
GIS & Spatial Analysis for Public Health

Varun Goel

Outline

- In-class Exercise 1
- Navigate to:
  - https://gisph.netlify.app
- Space and place
- What is GIS?
- Maps as Models
- Spatial Cognition
- Abstraction

In-class Exercise 1

- Navigate to Course Website
  - Materials Ụ Exercises

Space vs Place

- Space
  - Focus on location and distance
  - Main concern for most quantitative geographic analysis
- Place
  - Places have a deeper meaning
    - Representations or symbols
    - Interpreted or experienced by people
    - Embedded with history and meaning

What is GIS?

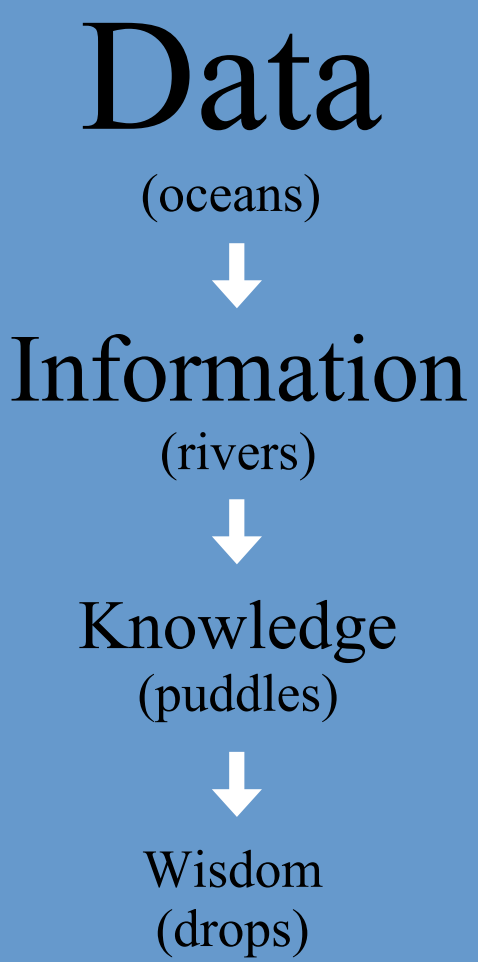
- Geographic Information Systems
  - Geographic, Geospatial, Geo
    - Newer alternative: *Spatial* Information Systems
  - Geographic Information (GI)
    - Information about places, objects, and events on Earth and the relationships between them

What is GIS?

- Information Systems
  - Hardware, software, and people needed to collect, manage, analyze, and report data for the purpose of decision making or scientific investigation
    - Not a simple data repository
  - Used to achieve higher levels of understanding
    - In GIS, the information is generally spatially-referenced, i.e., has a *location*

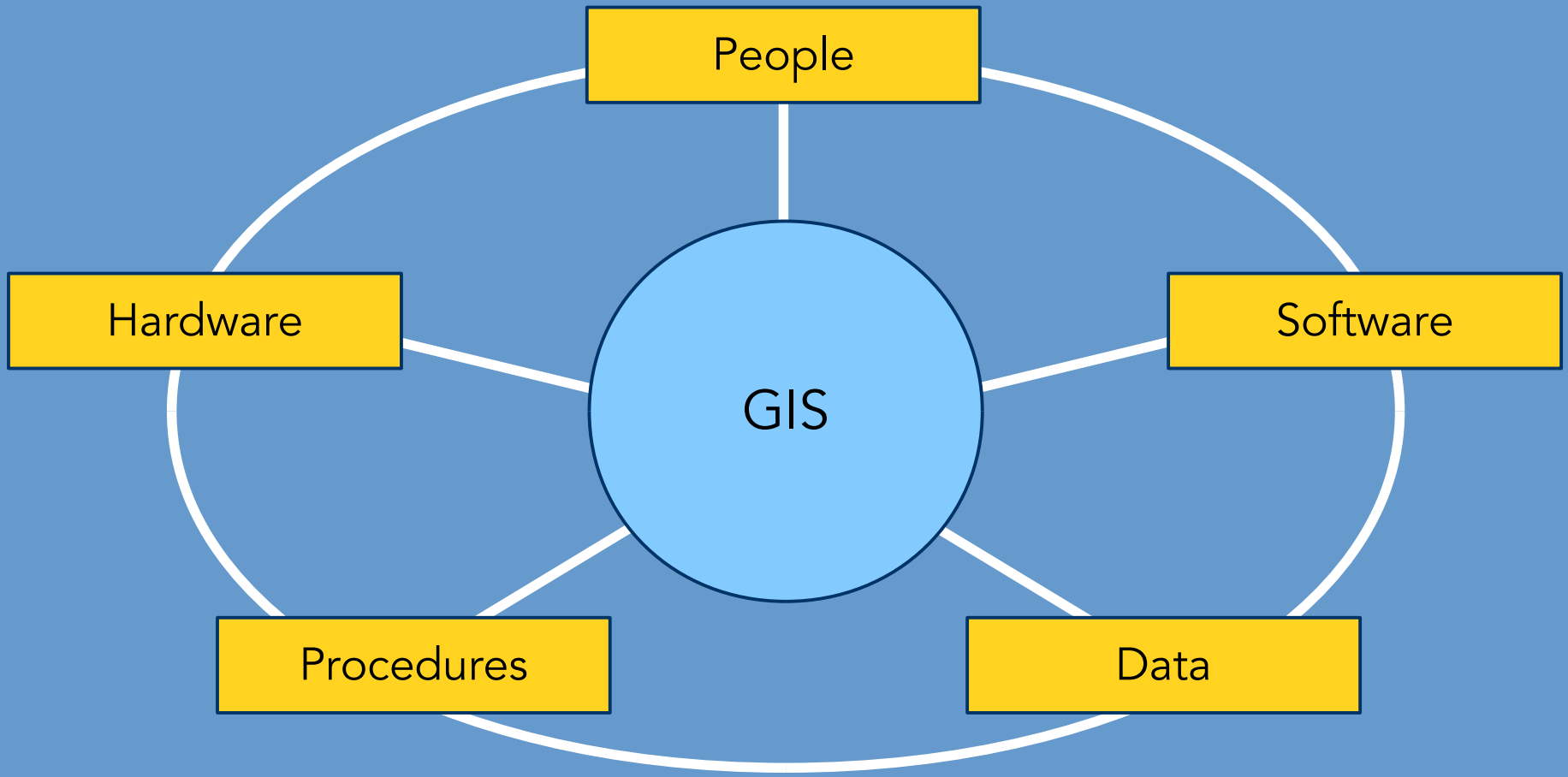
What is GIS?

- Information Systems

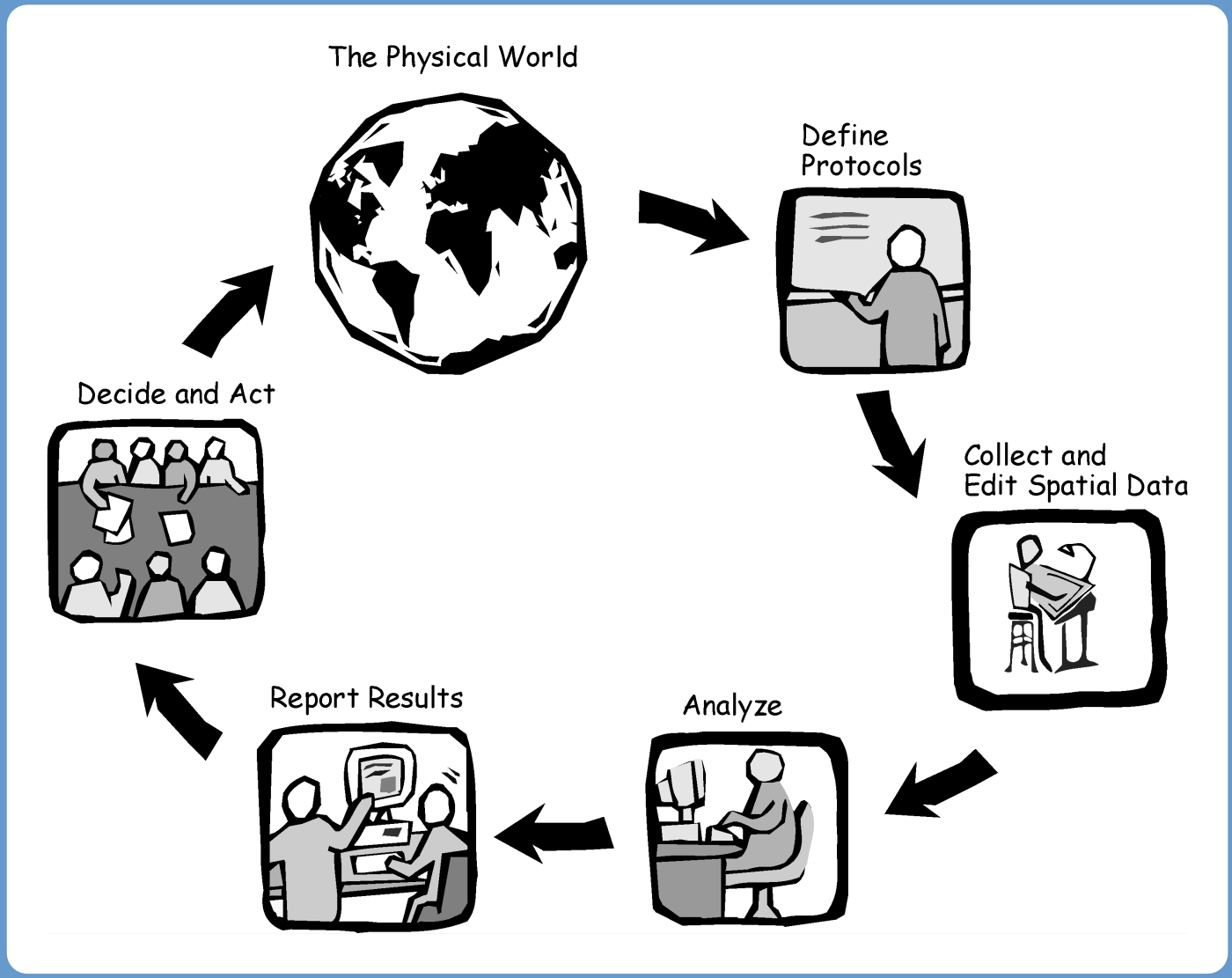


- **Data**: facts and figures
- **Information**: data organized such that it is useful
- **Knowledge**: accumulated and integrated information on a topic over some period of time and across a broad range of situations
- **Wisdom**: application of universal principles, reason, and knowledge to discern what is true and right

GIS is...

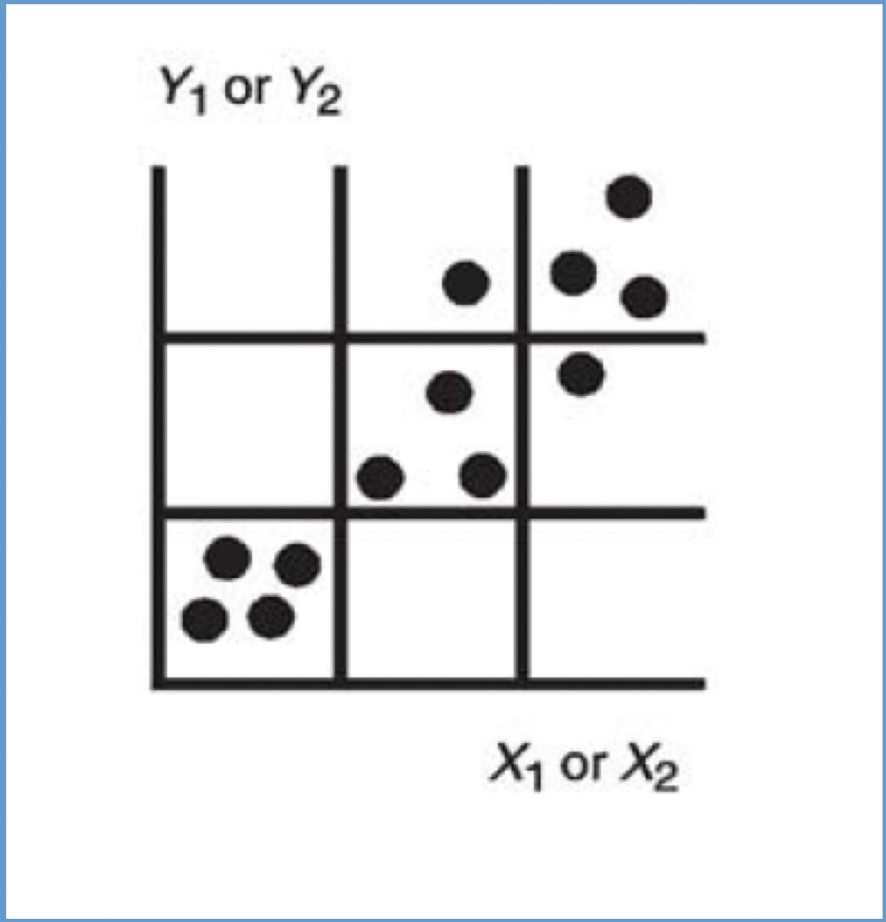


Processing View of GIS

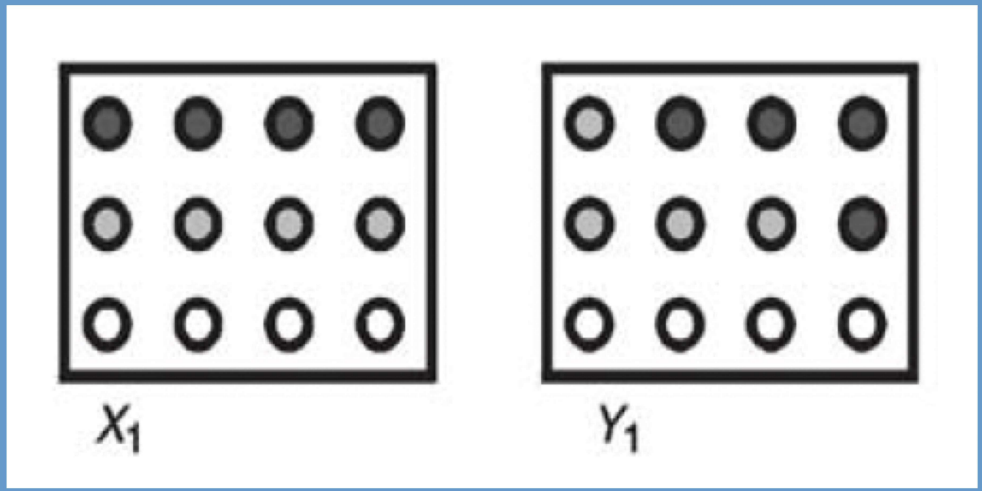


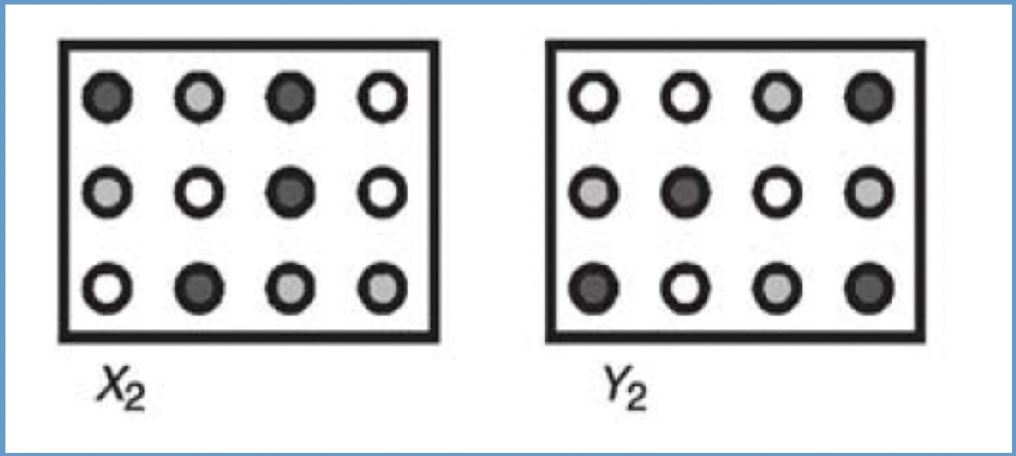
Why use a GIS

- Let X_1 or X_2 be levels of lead in blood
- Let Y_1 or Y_2 be a measurement of blood pressure



Why use a GIS





Maps as Models

- Map definition
  - A **representation**, usually on a flat surface, of the whole or part of an area
  - Something that **represents** with a clarity suggestive of a map
- Maps are used to communicate information to the map viewer

Meaningful Representation

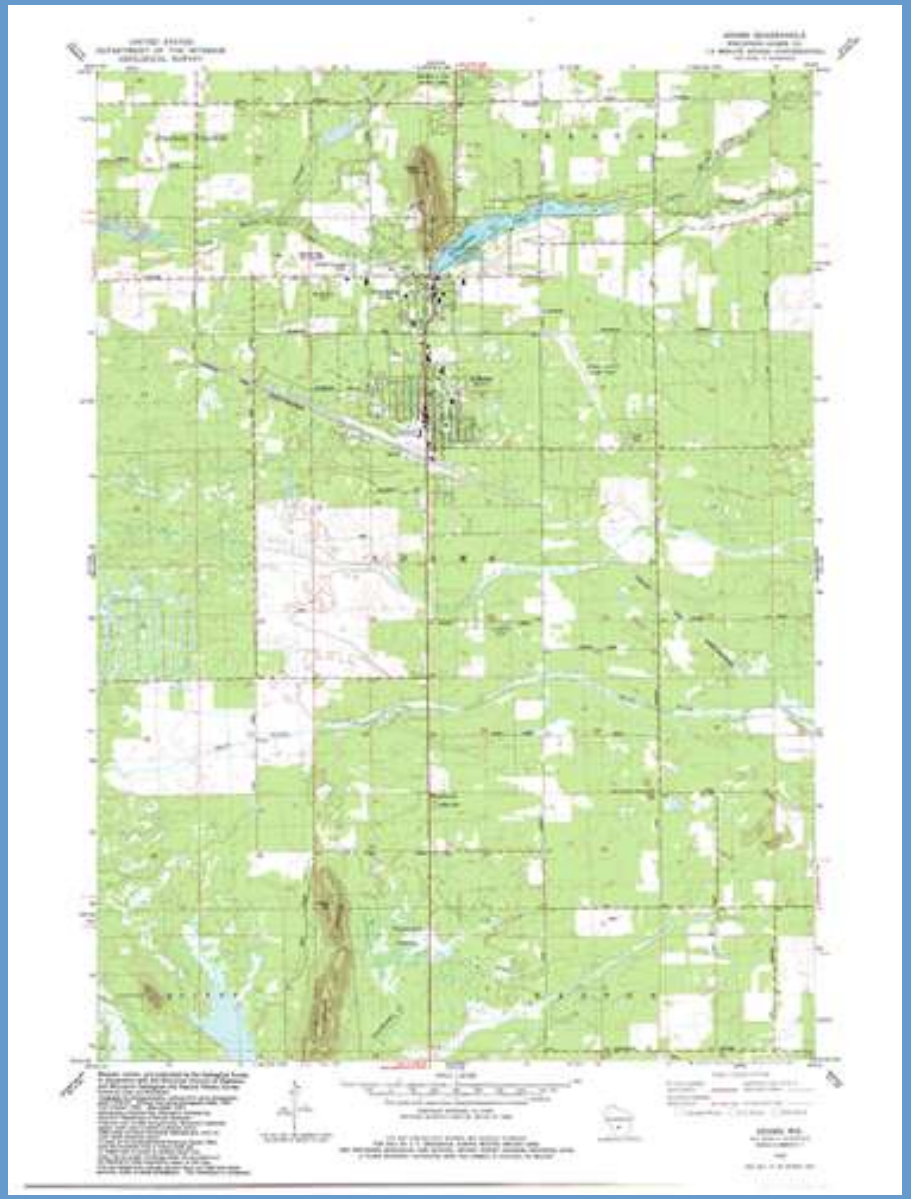
- Marks on paper or computer screen that stand for definable phenomena on Earth's surface
  - Verifiable rules are applied
    - When a scientific approach is used
  - Logical correspondence between marks and referents
  - A form of data storage
  - Content is selective,map-maker has control

Map Types

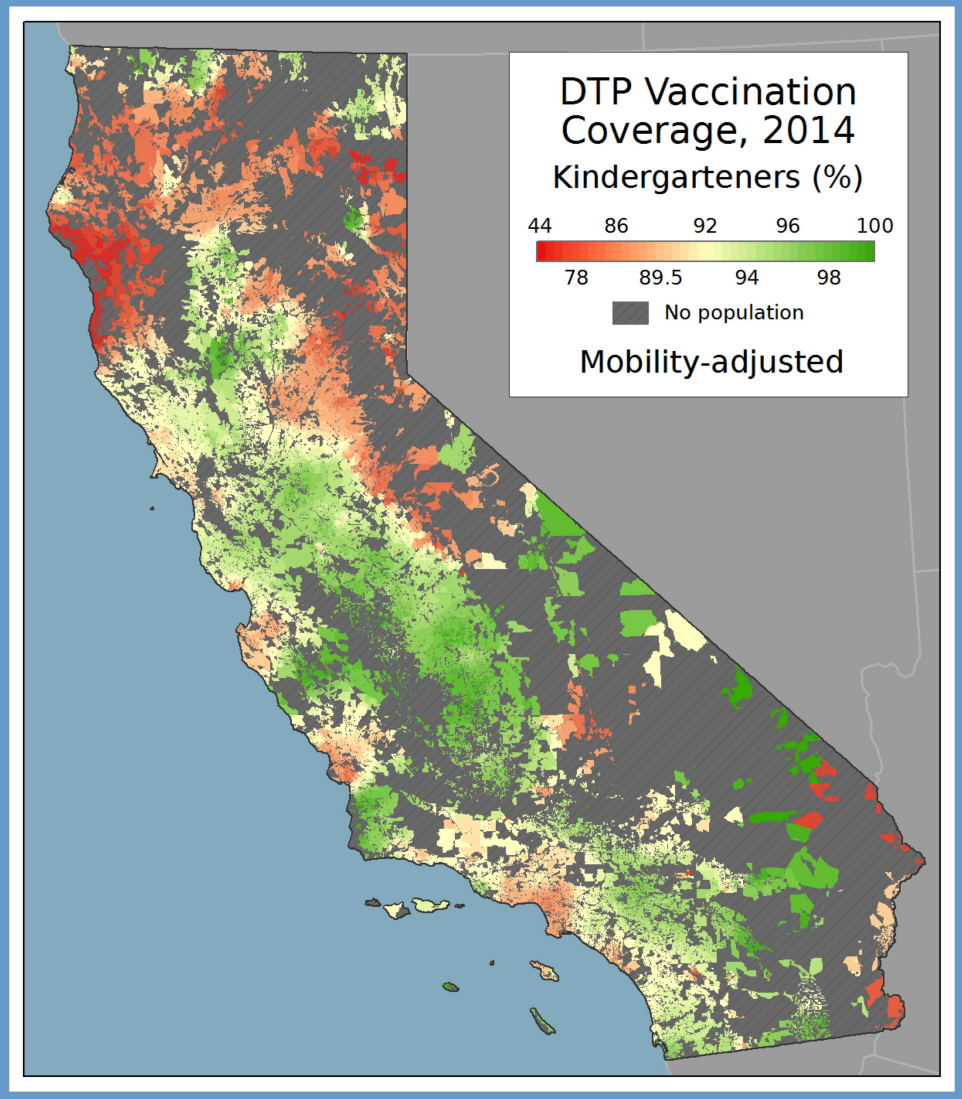
- Reference
  - Goal: communicate spatial association between various phenomena
    - e.g., roads, settlements, administrative boundaries, water bodies, etc.
- Thematic
  - Goal: communicate the distribution of a single property or relationships among several
    - Usually shown at small scale
      - *Small* scale equals *large* areal extent
    - Not restricted to any subject matter

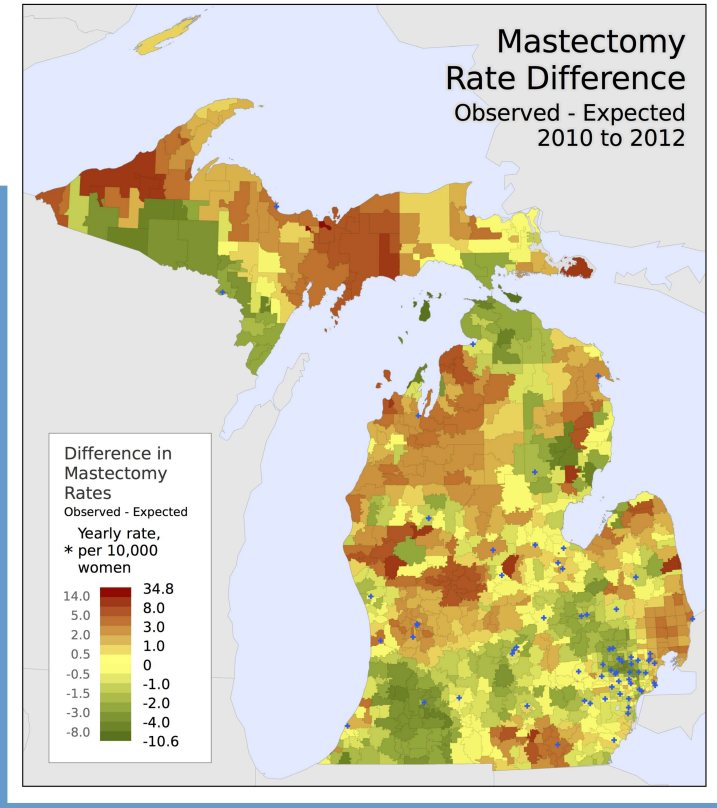
Reference Maps

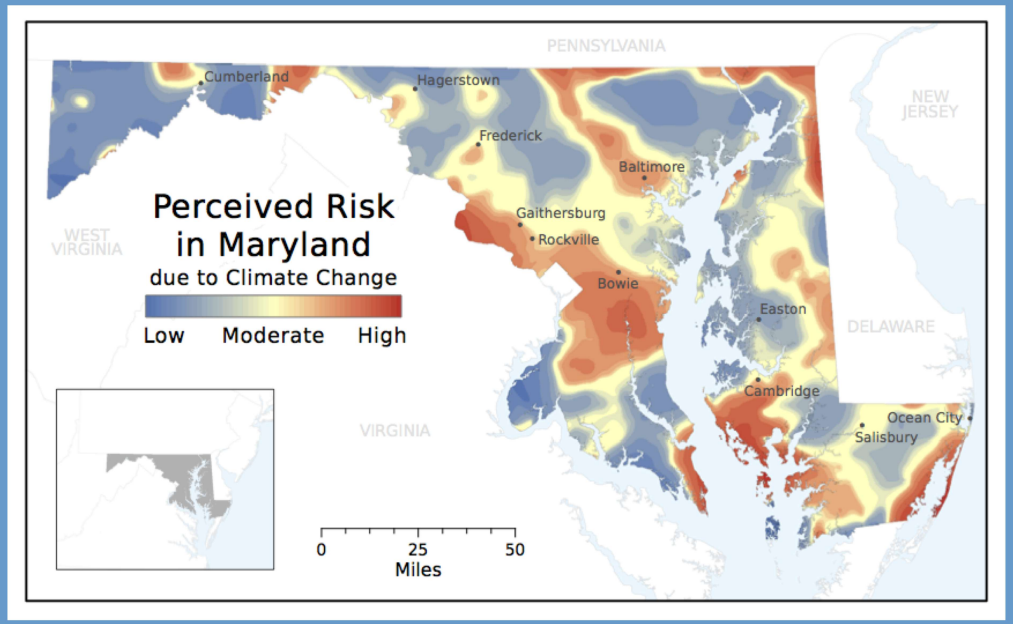
- Example: USGS Topographic Maps
  - Originally printed, now available as Digital Raster Graphics (DRG) files



Thematic Maps

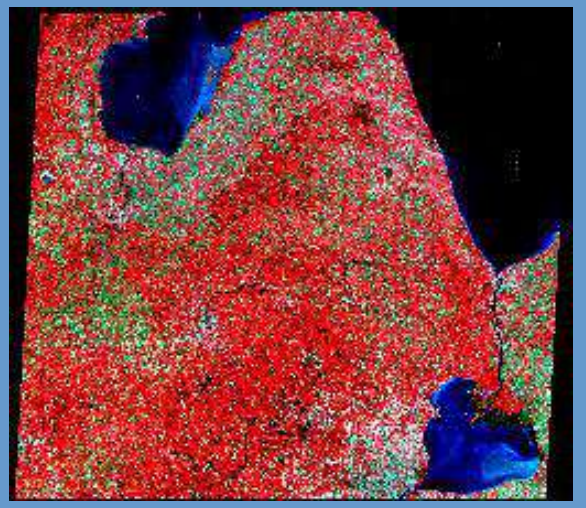


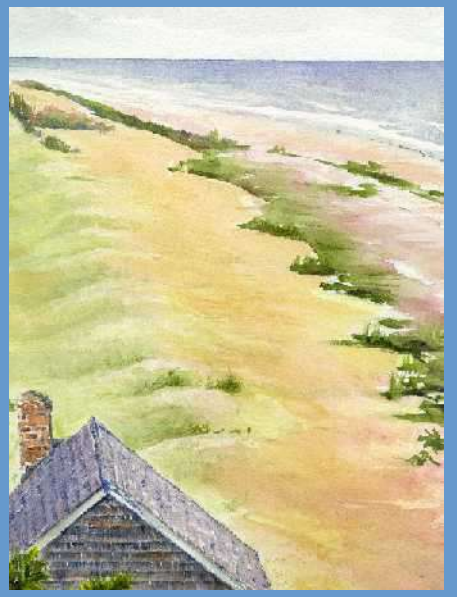




Non-map Representations

- Air photos and satellite imagery
  - All inclusive
- Photos (snapshots) and drawings
  - Spatial relationships may be unobservable
- Written word





"Just beyond the southwestern corner of Adams County is one of the world's truly awesome family-oriented commercial entertainment areas, the Wisconsin Dells."

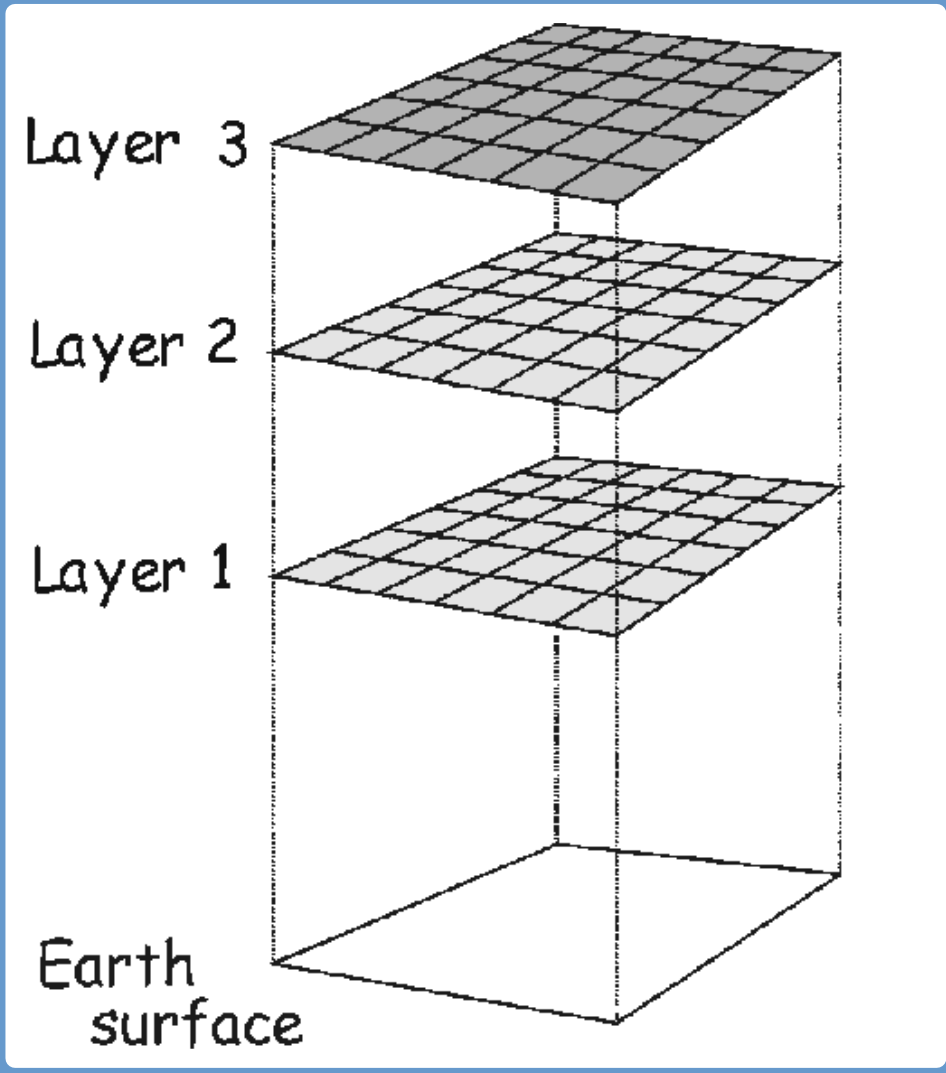
Hart, 1998 *The Rural Landscape.*

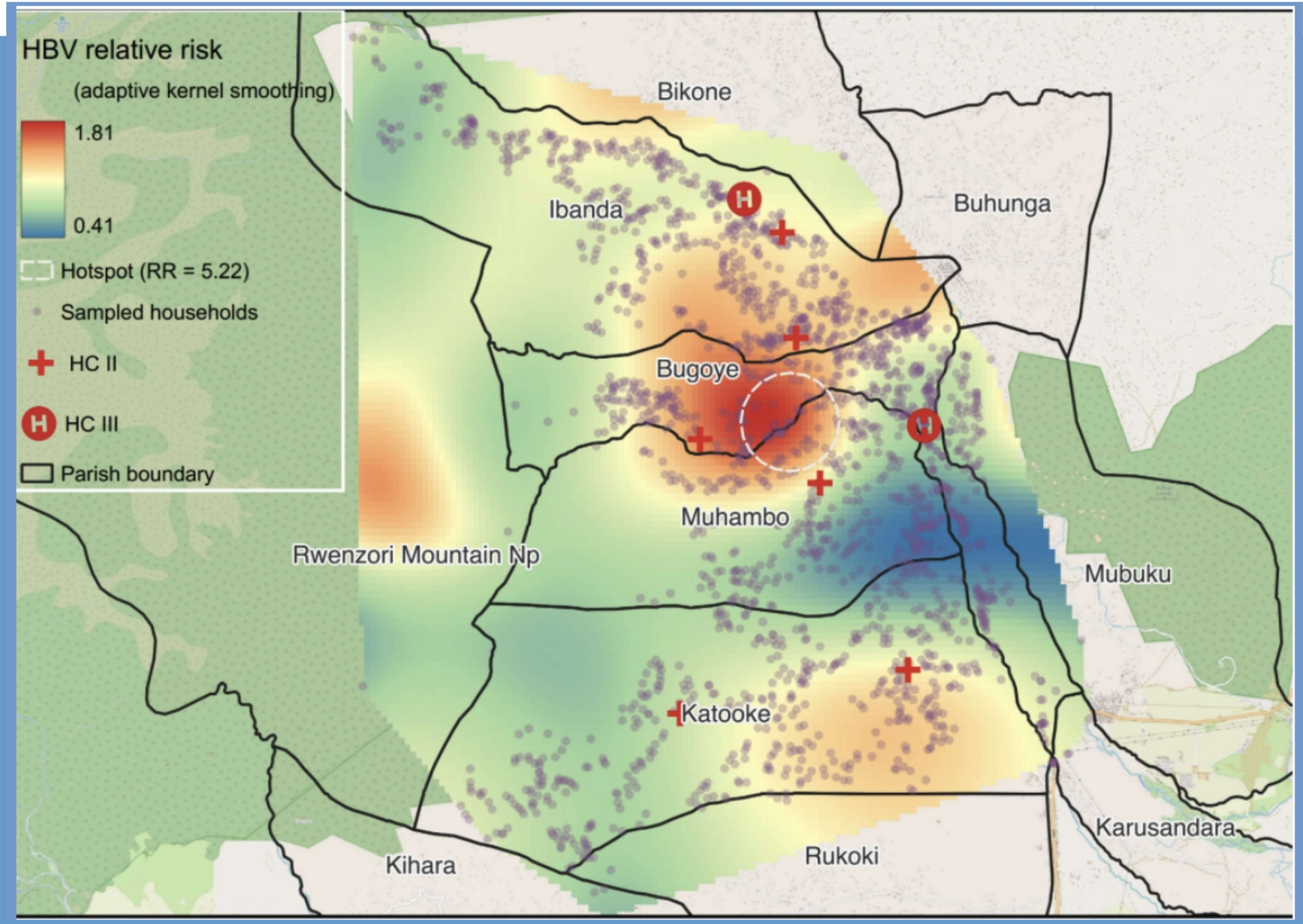
GIS and Maps

- Point
  - The map is a universal communication tool that has proved to be one of the strengths of GIS
- Counterpoint
  - The map metaphor is probably the greatest hindrance to further advancement in GIS analysis and applications

Basic Structure of GIS

- Information is organized in data layers
- Each layer represents a single "theme"
- Layers have their own internal logic




HBV relative risk
(adaptive kernel smoothing)
1.81
0.41
Hotspot (RR = 5.22)
Sampled households
HC II
HC III
Parish boundary
Bikone
Ibanda
Buhunga
Bugoye
Muhambo
Rwenzori Mountain Np
Mubuku
Katooke
Karusandara
Kihara
Rukoki

Bone Marrow Transplantation (2015), 1–8

www.nature.com/bmt

ORIGINAL ARTICLE

Geographic access to hematopoietic cell transplantation services in the United States

PL Delamater[1] and JP Uberti[2]

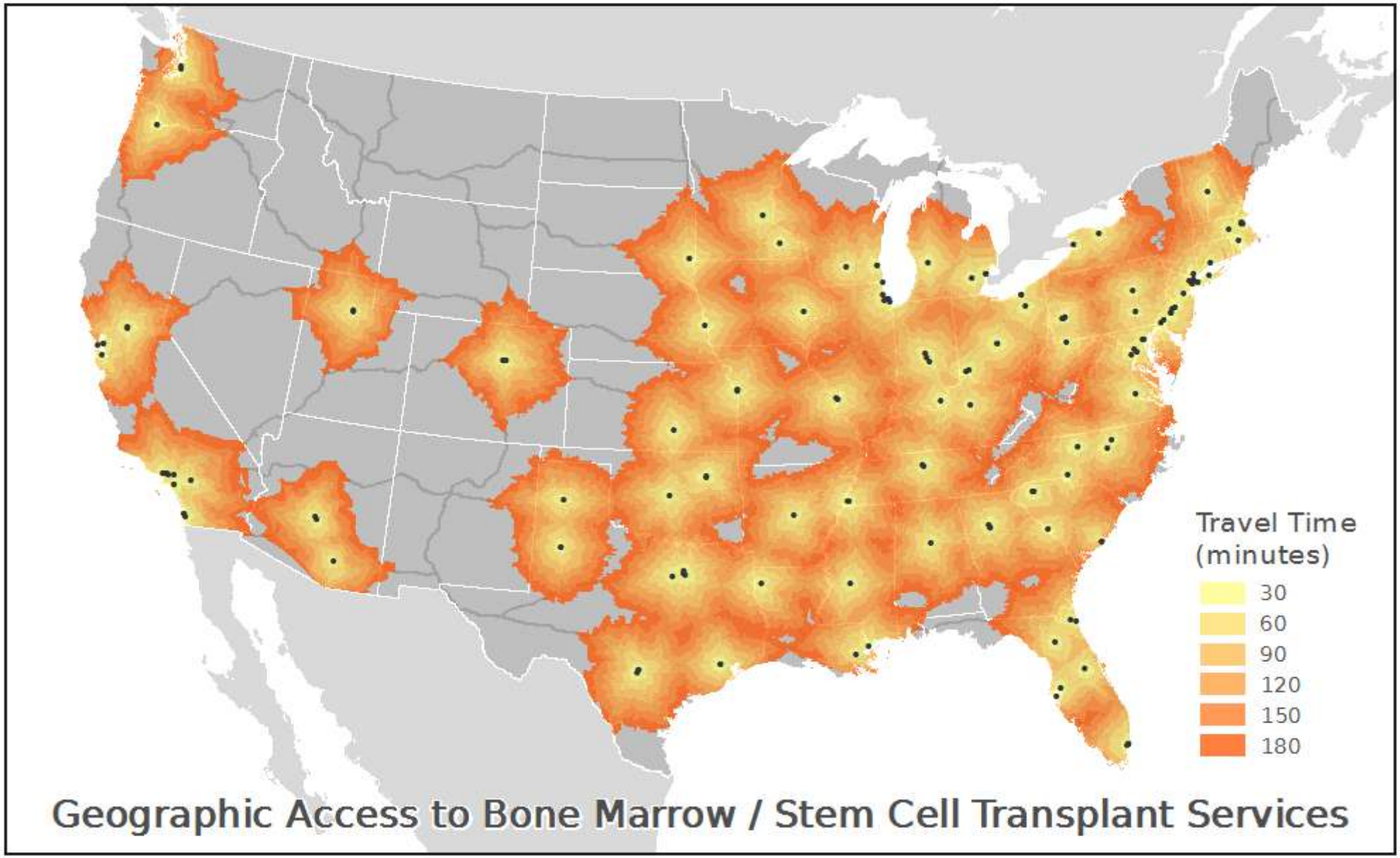
The use of hematopoietic cell transplantation (HCT) has risen in recent years and additional increases are projected in the near- and long-term future. The complex nature of HCT, along with its potentially rigorous follow-up care requirements, presents numerous potential barriers to accessing this important service (for example, financial considerations, donor availability and sociodemographic factors). The distance between a patient and an HCT facility also appears to be an important factor in both HCT use and outcomes. We provide the first comprehensive and detailed evaluation of geographic access to HCT services for the adult (18+ years) and pediatric (0–17 years) populations in the United States. Population-level access is examined as well as detailed gender, race/ethnicity and age breakdowns. Generally, access to HCT services appears to be quite high throughout the United States, as 48%, 78.6% and 94.7% of the 18+ years age population has 30, 90 and 180 min access (respectively) to an adult HCT facility and 42.5%, 72% and 91.5% of the 0–17 years age population has 30, 90 and 180 min access (respectively) to a pediatric facility.

Bone Marrow Transplantation advance online publication, 12 October 2015; doi:10.1038/bmt.2015.246

INTRODUCTION

Hematopoietic cell transplantation (HCT) is a highly specialized treatment that requires a comprehensive and technologically sophisticated clinical infrastructure. For many patients facing life-threatening oncologic and hematologic diseases, HCT is the only known curative therapy.[1] Improvements in transplant

or relocate nearer to the HCT facility for the duration of the post-transplantation period. Many HCT transplant centers *require* allogeneic transplant patients to relocate nearer to the facility for the first 100 days of post-transplant care. For autologous HCT patients, these concerns appear less salient, as most do not receive follow-up care at the HCT facility after discharge.[3]


Travel Time
(minutes)
30
60
90
120
150
180
Geographic Access to Bone Marrow / Stem Cell Transplant Services

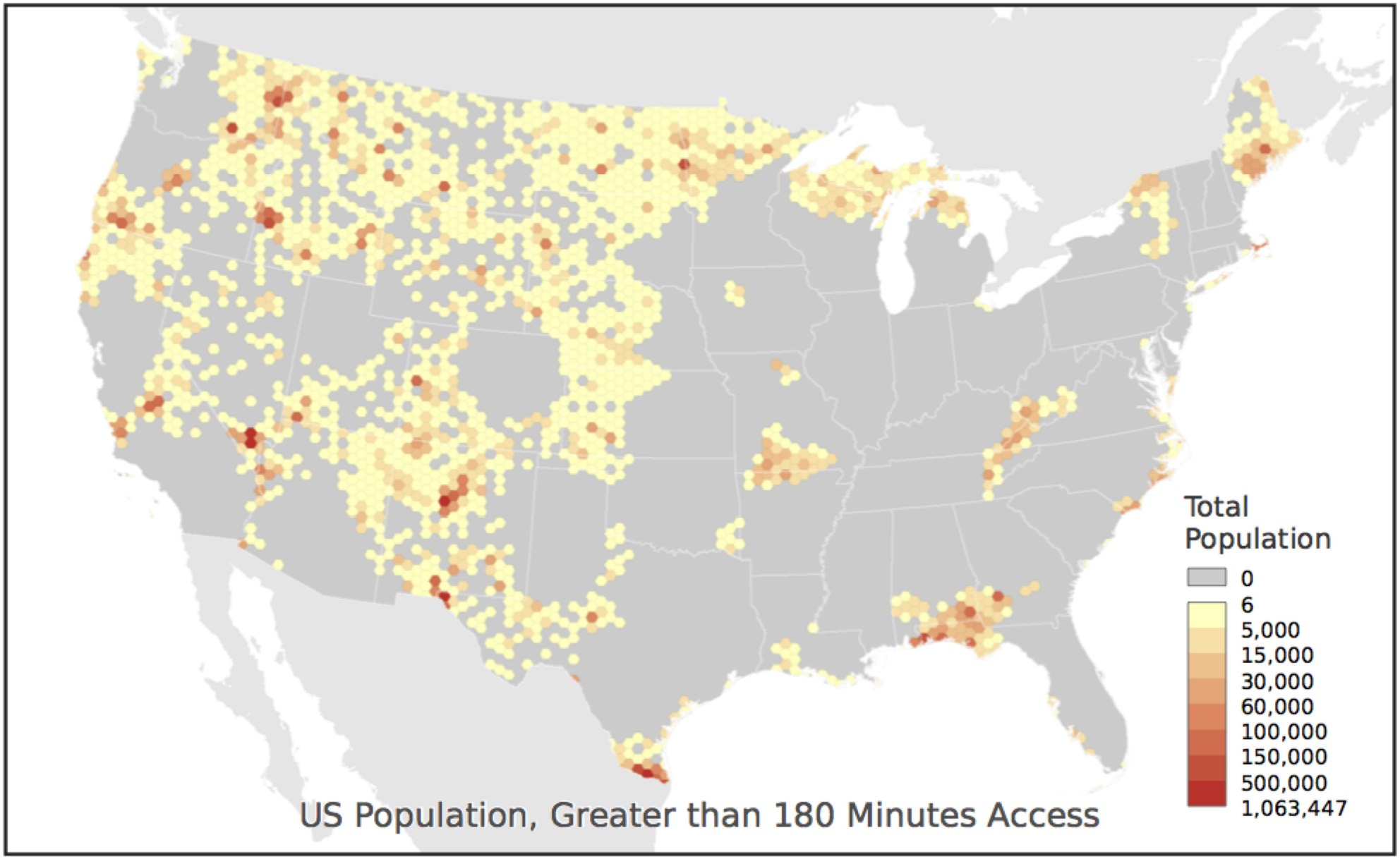

Total Population
0
6
5,000
15,000
30,000
60,000
100,000
150,000
500,000
1,063,447
US Population, Greater than 180 Minutes Access

Table 2. Geographic access to HCT transplant facilities

	Adult							Pediatric						
State	*Population*	*30 min*	*60 min*	*90 min*	*120 min*	*150 min*	*180 min*	*Population*	*30 min*	*60 min*	*90 min*	*120 min*	*150 min*	*180 min*
Alabama	3 647 277	16.7	28.1	46.2	69.3	85.1	88.6	1 132 459	17.0	27.8	46.1	69.2	85.2	88.7
Arizona	4 763 003	71.2	79.9	82.3	86.6	89.7	92.9	1 629 014	50.4	78.8	83.1	86.2	88.9	92.7
Arkansas	2 204 443	18.4	34.6	50.4	68.9	84.8	95.7	711 475	2.0	4.5	10.2	15.8	38.9	55.7
California	27 958 916	57.1	78.0	85.0	90.9	93.0	97.4	9 295 040	59.0	70.7	81.9	89.3	91.1	96.2
Colorado	3 803 587	49.5	62.1	80.1	84.7	87.5	89.6	1 225 609	51.4	64.2	81.8	86.3	88.5	90.4
Connecticut	2 757 082	46.1	97.2	100.0	100.0	100.0	100.0	817 015	46.2	88.9	99.4	100.0	100.0	100.0
Delaware	692 169	60.0	74.2	85.8	99.9	100.0	100.0	205 765	57.7	74.5	84.0	99.1	100.0	100.0
Washington DC	500 908	100.0	100.0	100.0	100.0	100.0	100.0	100 815	100.0	100.0	100.0	100.0	100.0	100.0
Florida	14 799 219	49.8	72.4	82.3	87.8	92.4	94.1	4 002 091	29.9	44.5	57.9	78.0	87.7	93.1
Georgia	7 196 101	39.2	59.2	72.7	84.7	93.1	97.3	2 491 552	26.7	56.1	67.6	80.3	91.6	97.0
Idaho	1 138 510	31.5	40.9	42.2	45.7	53.3	72.3	429 072	32.3	42.2	43.5	46.8	53.4	63.8
Illinois	9 701 453	60.0	77.7	90.1	96.2	99.2	100.0	3 129 179	52.1	73.7	82.5	90.3	98.0	100.0
Indiana	4 875 504	32.0	55.9	75.6	93.2	99.9	100.0	1 608 298	32.5	53.0	72.7	89.8	99.9	100.0
Iowa	2 318 362	10.3	25.2	44.4	81.5	95.0	99.5	727 993	9.2	24.3	38.9	78.4	91.3	97.8
Kansas	2 126 179	42.8	56.7	72.4	80.7	89.4	92.5	726 939	25.0	36.1	42.2	47.1	61.3	81.1
Kentucky	3 315 996	39.0	55.4	70.3	85.3	95.8	99.1	1 023 371	29.5	40.6	61.4	74.8	85.8	93.2
Louisiana	3 415 357	28.9	39.8	63.0	75.1	92.3	99.6	1 118 015	18.8	28.2	48.3	56.6	73.3	86.7
Maine	1 053 828	0.0	0.1	2.4	12.6	33.1	50.4	274 533	0.0	0.0	2.3	10.5	32.0	47.4
Maryland	4 420 588	71.4	88.9	94.6	97.7	99.6	100.0	1 352 964	69.9	89.0	93.6	96.9	99.5	100.0
Massachusetts	5 128 706	68.5	90.8	94.5	96.0	96.4	96.4	1 418 923	45.5	81.9	94.4	96.6	97.2	97.2
Michigan	7 539 572	44.6	71.0	84.9	90.8	93.3	94.8	2 344 068	46.1	73.4	87.1	92.5	94.7	95.9
Minnesota	4 019 862	52.2	66.4	75.3	81.1	87.2	90.7	1 284 063	52.3	68.3	76.4	80.7	86.0	89.9
Mississippi	2 211 742	20.2	32.5	54.2	82.5	96.3	100.0	755 555	20.7	33.8	54.2	81.9	96.2	99.9
Missouri	4 563 491	42.7	54.4	60.6	73.4	82.5	94.6	1 425 436	43.9	56.2	62.4	71.4	79.2	84.9
Montana	765 852	24.9	29.9	36.3	44.0	62.6	75.2	223 563	15.0	17.6	19.5	21.3	30.7	33.4
Nebraska	1 367 120	37.7	54.7	63.6	69.9	78.6	85.0	459 221	40.0	55.6	63.2	70.5	79.0	85.3
Nevada	2 035 543	0.0	0.0	0.0	2.3	16.2	21.3	665 008	0.0	0.0	0.0	0.2	0.2	0.3
New Hampshire	1 029 236	14.9	65.8	92.9	97.8	99.7	99.9	287 234	0.5	48.2	74.6	90.4	96.5	98.6
New Jersey	6726 680	70.4	94.8	99.4	100.0	100.0	100.0	2 065 214	70.0	95.6	99.6	99.9	100.0	100.0
New Mexico	1 540 507	38.4	48.9	52.4	57.4	66.8	69.7	518 672	36.0	45.9	48.9	53.7	57.3	60.5
New York	15 053 173	72.7	83.9	89.9	94.4	99.6	99.8	4 324 929	69.3	84.0	89.9	93.6	97.8	98.8
North Carolina	7 253 848	34.2	58.7	75.6	87.2	93.3	97.1	2 281 635	25.6	48.7	70.2	82.7	91.9	97.5
North Dakota	522 720	0.0	0.0	0.0	0.0	0.0	0.1	149 871	0.0	0.0	0.0	0.0	0.0	0.0
Ohio	8 805 753	47.1	74.1	92.7	97.9	99.9	100.0	2 730 751	47.4	79.3	91.6	97.3	99.4	100.0
Oklahoma	2 821 685	49.9	63.1	79.4	91.3	95.4	99.0	929 666	29.6	36.2	46.3	76.9	86.1	94.3
Oregon	2 964 621	41.2	54.8	62.4	73.1	75.7	80.5	866 453	41.7	58.0	65.4	75.1	77.0	81.8
Pennsylvania	9 910 224	46.8	77.1	91.2	98.8	99.9	100.0	2 792 155	44.4	72.5	85.1	95.8	99.6	100.0
Rhode Island	828 611	83.4	99.9	99.9	99.9	99.9	99.9	223 956	0.0	59.9	97.6	99.9	99.9	99.9
South Carolina	3 544 890	29.8	49.9	75.8	84.2	93.9	99.5	1 080 474	10.7	19.3	40.9	74.9	93.3	99.7
South Dakota	611 383	25.2	33.6	43.8	50.6	57.1	60.0	202 797	0.0	0.0	0.0	1.4	3.1	28.6
Tennessee	4 850 104	40.2	61.0	77.6	96.2	99.7	100.0	1 496 001	32.4	46.9	56.3	66.3	74.6	86.9
Texas	18 279 737	45.1	64.7	75.2	81.8	86.8	90.6	6 865 824	47.8	63.4	70.6	75.1	79.5	83.4
Utah	1 892 858	47.8	79.1	82.1	86.2	88.3	89.7	871 027	39.9	77.4	82.4	86.6	88.5	90.1
Vermont	496 508	35.2	67.0	90.2	99.1	100.0	100.0	129 233	0.0	0.0	0.0	2.4	16.1	40.5
Virginia	6 147 347	54.2	69.6	83.9	94.0	97.9	99.0	1 853 677	31.7	51.5	66.2	73.6	90.1	96.3
Washington	5 143 186	41.0	64.5	72.6	76.2	80.6	86.3	1 581 354	37.7	63.1	70.8	73.9	78.6	83.9
West Virginia	1 465 576	7.9	22.2	36.3	46.1	70.4	93.7	387 418	0.0	6.0	22.4	32.2	46.1	60.2
Wisconsin	4 347 494	40.0	60.8	78.1	92.6	96.7	98.7	1 339 492	36.4	62.7	78.5	93.5	97.3	98.9
Wyoming	428 224	0.0	0.0	2.2	20.5	36.6	48.7	135 402	0.0	0.0	2.9	22.0	35.0	48.1
USA	*232 984 735*	*48.0*	*67.5*	*78.6*	*86.6*	*91.7*	*94.7*	*73 690 271*	*42.5*	*61.1*	*72.0*	*81.0*	*87.2*	*91.5*

Abbreviation: HCT, hematopoietic cell transplantation. Access figures are reported as percent of the state population. In the following figures, access to any HCT service location (non-state-specific) is included.

Table 1. Summary statistics for adult and pediatric access to HCT facilities in the conterminous United States

	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) years	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 minority populations	34 111 855	53.5	67.7	76.6	83.8	88.6	92.3
Adult (18+) years	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 minority populations	76 510 262	62.0	76.2	83.5	88.8	92.5	95.0

Abbreviations: AIAN, *American Indian or Alaska Native*; HCT, hematopoietic cell transplantation; HWPI, *Native Hawaiian or Other Pacific Islander* and Multiple is *Two or more races reported*. For the access columns, the figures are in percent of the total group population. All minority populations entry includes the sum of all non-White populations.

Creating Representations

- Spatial Cognition
  - Our understanding of the geographical world
- Measurement
  - Process of extracting data from the world
- Symbolization
  - Established rules for relating marks to real world objects, events or properties

Spatial Cognition

- Mental processes involved in gaining and using knowledge about spatial environments
  - Perception, memory, language, learning, problem solving
  - Highly complex set of interactions
  - Major concerns for GIS
    - Observation, description, analysis
      - Real world Ų Data Ų Knowledge
    - Understanding of maps
      - Communication of spatial information

Abstraction

- The Earth is infinitely complex and also infinitely large
  - Far too much information to model the world perfectly (extent and detail)
  - Simplification is necessary
    - Some information must be ignored or aggregated

Abstraction

- The process of ignoring or simplifying information in a model is called abstraction
  - Very important for understanding and thinking about spatial data and GIS/spatial analysis
  - Levels of abstraction for GI
    - Real world Ų Data Model Ų Data Structure

Levels of Abstraction

- Real World
  - The world as it is, in all its complexity
- Data Model
  - This stems from our conceptual view of the world
  - The world of things noticed and named (ontology, semantics)
    - Some things are more "solid" than others
      - Physical features, e.g., buildings, rivers, forests
      - Is there such a thing as a habitat type or an ethnic group? How is it to be defined and represented?

Levels of Abstraction

- Data Structure
  - Formal symbolic representation of specific things in the data model
  - Organized set of files for managing defined entities in the data model (formalized in the data structure)
- File Structure
  - Computer representation of files

Levels of Abstraction

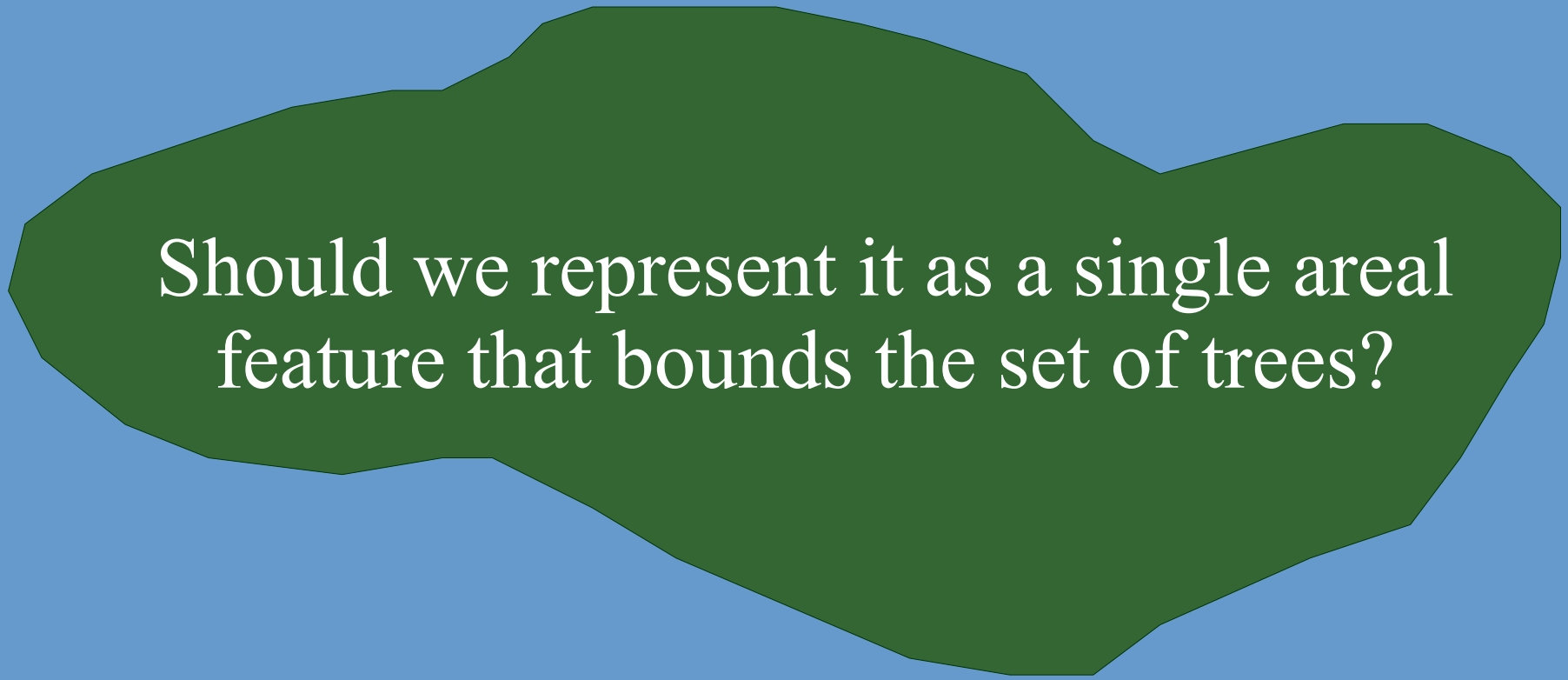
S/he can't see the forest for the trees...

Levels of Abstraction

Consider a forest...

Levels of Abstraction

Consider a forest...



Levels of Abstraction

Consider a forest...

...or the set of trees?

Components of Geographic Information

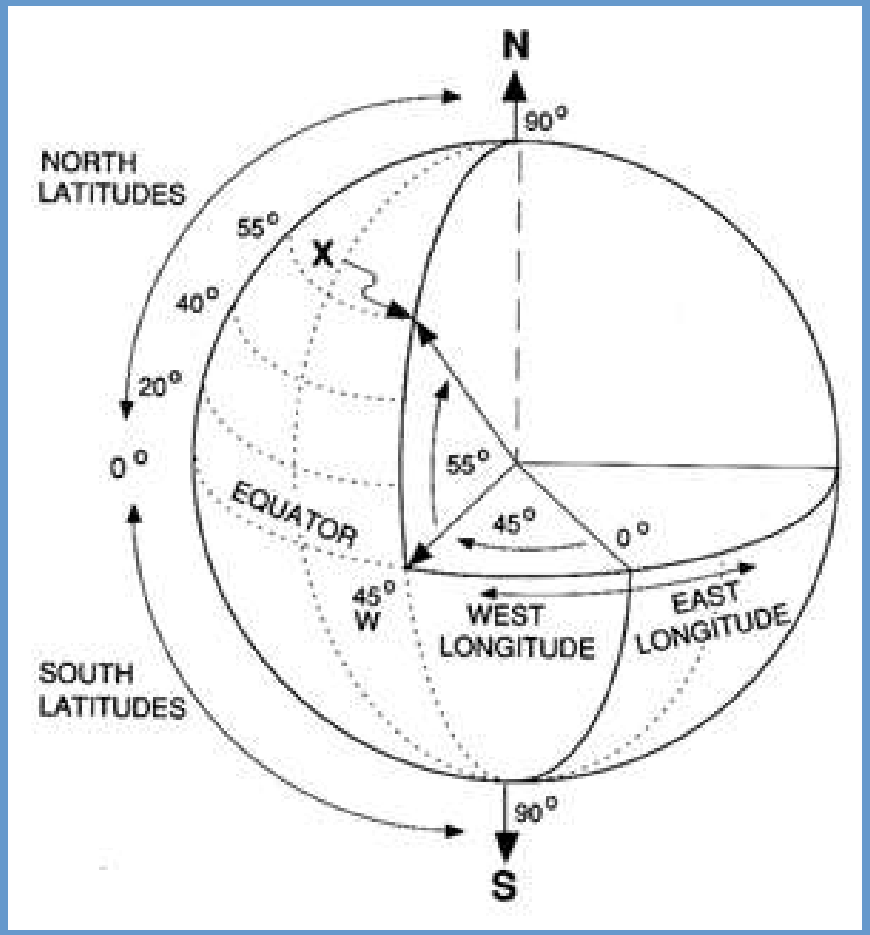
- Location
  - Often defined in 2-D space, but can be 3-D
- Attribute
  - Some measurable or observable property
- Time
  - Often at a single time, but may include variable time
- Metadata
  - Describes the data and assumptions

Making Measurements

- Measurements for GI require:
  - A system for precise measurement of location
  - An attribute measurement scheme and acceptance of attribute definitions
    - What characteristics are important and how do we describe and or measure these characteristics?
  - Spatial, thematic, and temporal aggregation or sampling framework
    - Measuring everything everywhere all the time is impossible

Geographic Coordinates

- On a sphere, referencing is made using angles, using the center of the Earth as the origin
- Latitude
  - Measured N-S relative to Equator
- Longitude
  - Measured E-W relative to Prime Meridian



Measuring Attributes

- Attributes describe the properties of objects or locations
- Almost any measurement device can be used to measure attributes for GI
  - e.g., remote sensor, weather station, flow gauge, in-person or online survey
- Can be considered *variables* and are often stored as columns in a data table

Levels of Measurement

- Nominal
  - Simplest type of attribute
  - An identifier value
    - Name, letters, colors, numbers
      - Numeric nominal attributes should never have any mathematical operations applied to them (e.g., don't take the mean of US Social Security numbers)

Levels of Measurement

- Ordinal
  - Values that have a natural order or rank
    - Most mathematical operations should not be used
- Interval/Ratio
  - Numeric values (measurements)
  - Interval: differences between values make sense
  - Ratio: ratios between values make sense

Levels of Measurement

- Cyclic
  - Numeric, but non- "0" based
    - At the last value, cycles back to the first
    - Take care before performing mathematical operations on cyclic data

Levels of Measurement

- Level of measurement determines the mathematical operations that can/should be performed on and among variables
  - Nominal
    - Equivalence, count
  - Ordinal
    - Greater than / less than
  - Interval/Ratio
    - Difference and ratio
  - Cyclical
    - Special rules: e.g., compass directions

Announcements

- Next Week
  - Tues, Jan 20 on zoom
  - Thurs, Jan 22 no class. Work on Assignment 1
  - Spatial!

Keywords

- GIS
- Representation
- Thematic and reference map
- Spatial cognition, measurement, and symbolization
- Abstraction
  - Real world, data model, data structure
- Location, attribute, time, metadata
- Geographic coordinates, latitude and longitude
- Nominal, ordinal, interval/ratio, cyclic