GIS Test Drive

What a Geographic Information System Is and What it Can Do

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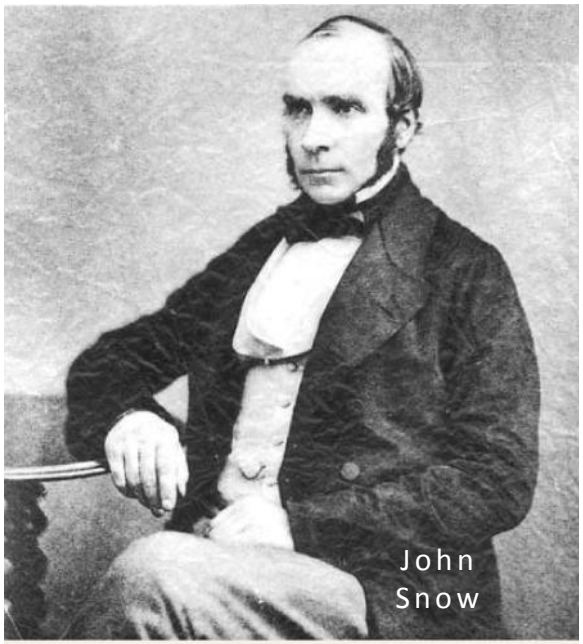
WHO AM I?

- Geospatial Analyst
  - M.S. in Geographic and Cartographic Sciences
  - Use GIS for spatial analysis and mapping
  - Communicate and teach others about GIS
- Applied geospatial and decision analysis to:
  - Access to justice
  - Environment
  - Renewable energy
  - Master planning
  - Health
  - National security and defense
- My passion is analyzing data to reveal hidden trends, better visualize information, and inform decisions.

Cholera
London
1853

How is this spreading? Through bad air?

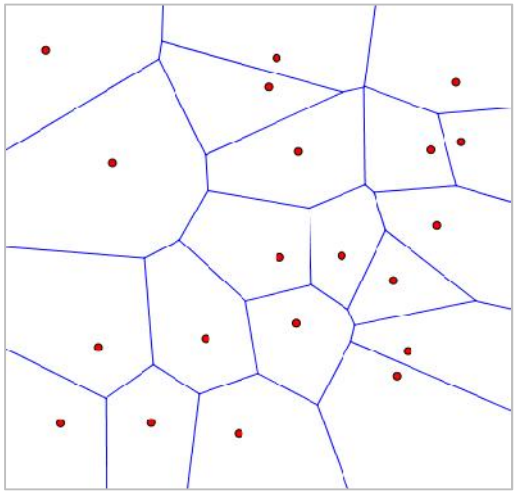


Cases and Deaths from Cholera.

NAME.	AGE.	DATE OF ATTACK.	DEATH.
John King	67	12 January	13 January.
James Cowdery	29	13 "	14 "
Peter Kelly	56	15 "	15 " (ill 16 hours.)
Jane Rivet	23	19 "	19 January.
Peter Sullivan	51	23 "	24 "
William Hodges	3	23 "	24 "
Ellen Donovan	46	23 "	24 " (ill 12 hours.)
Owen Mullins	71	24 "	25 January.
Catherine Joyce	39	24 "	24 " (same day.)
Mary Brown	59	24 "	24 January. (ill 8 hours.)
Elizabeth Murphy	27	25 "	25 January.
Peter Hennessey	15	25 "	25 "
Elizabeth Yarmouth	20	25 "	26 "
Mary Ann George	40	25 "	26 "
John Pimple	10	25 "	1 February.
Susan Arthur	41	26 "	26 January.
Bridget Pimple	12	26 "	31 "
Ann Buckley	18	- Ill about one week.	28 "
Jane Thompson	28	29 January	30 "
Catherine Donovan	13	2 February	3 February.

This was the last case and death.

Data, Analysis, and a Compelling Visualization



Voronoi Diagram reveals the midline distance between water pumps and finally a pattern and the source is discovered

WHAT'S MAPPING IS SO EFFECTIVE?

Our brains are wired for it

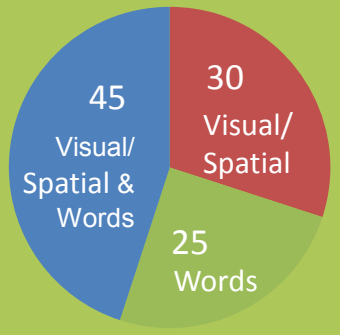
Our hippocampus is the center of spatial memory. Unlike other portions of the brain that filter out information that is inconsistent with one's world view, the hippocampus wants context to re-orient the mind to changing environment. Visual data and maps gives the viewer that opportunity.

Visual/spatial information

Picture is worth 1,000 words
Easy to assimilate
More compelling than text alone

75% of people think visual/spatially

45% uses both visual/spatial thinking and thinking in the form of words
30% of the population strongly uses visual/spatial thinking
25% thinks exclusively in words.



GOALS OF THIS PRESENTATION

Introduce Geographic Information Systems

What is this "system" exactly? And what is spatial thinking?

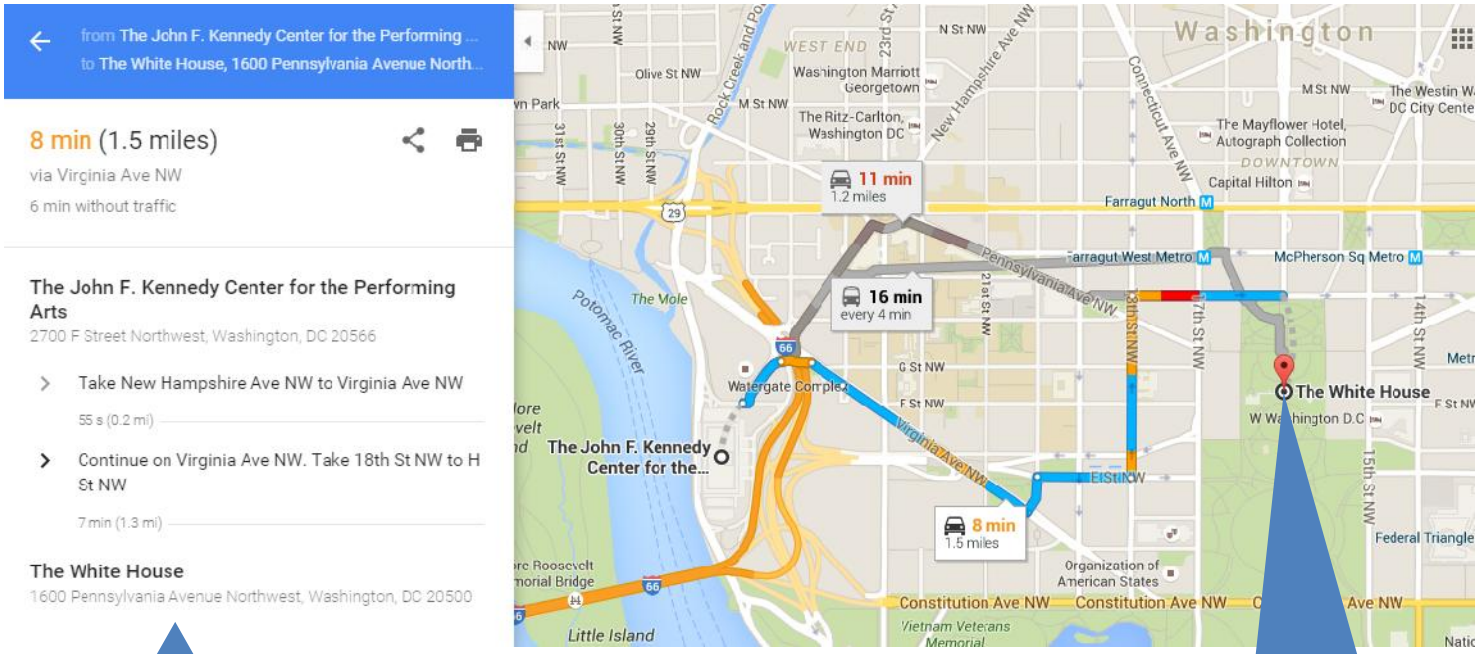
Reveal 10 cool things GIS can do

So that you know a good opportunity to use GIS when you see one

Provide real world examples of GIS in action

So that you can see practical applications of GIS

HOW IS GIS OFTEN PERCEIVED?



Source: Google maps

1. Calculate directions and drive times

2. Locate physical features

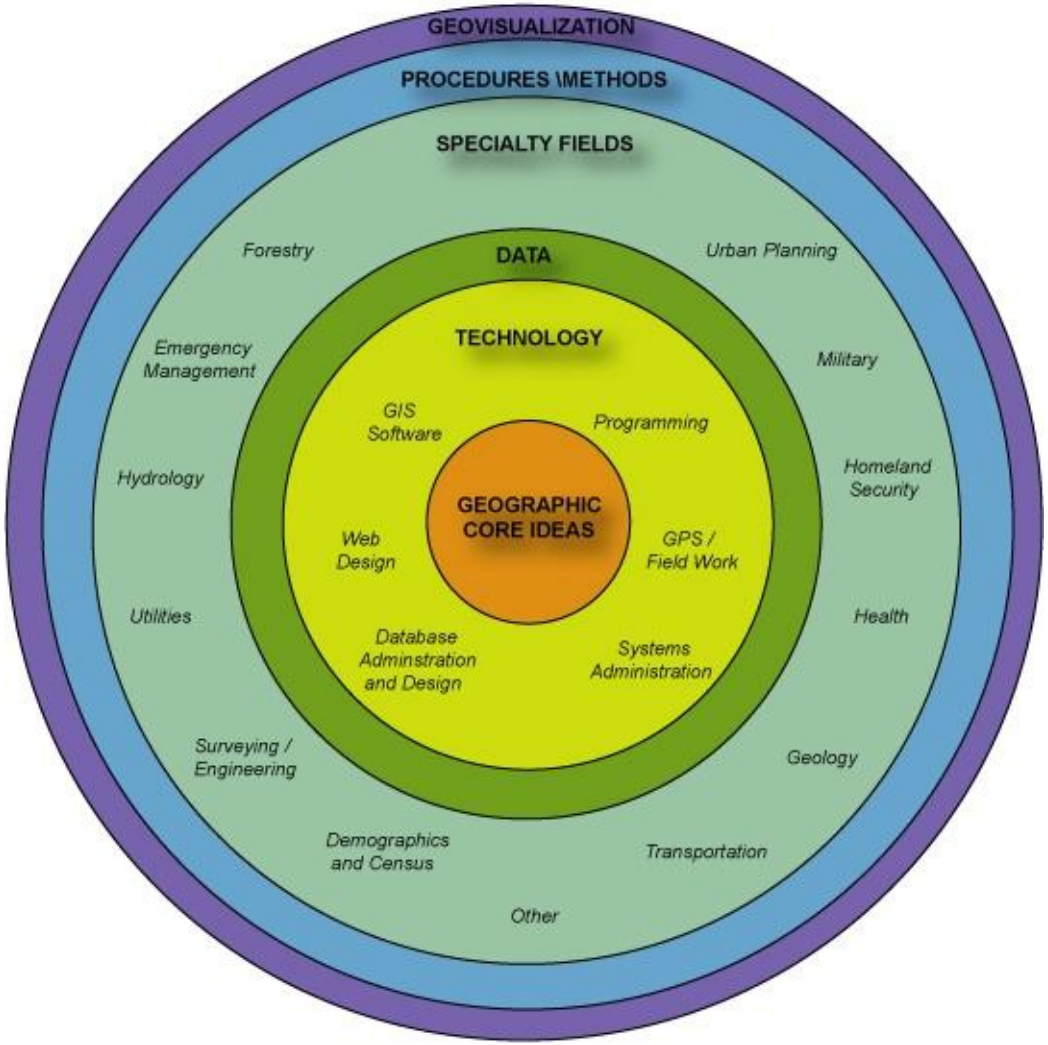
WHAT EXACTLY IS GIS?

Uses spatial data to help us visualize, question, analyze, interpret, and understand data to reveal relationships, patterns, and trends.

Thinking map

An experimental model

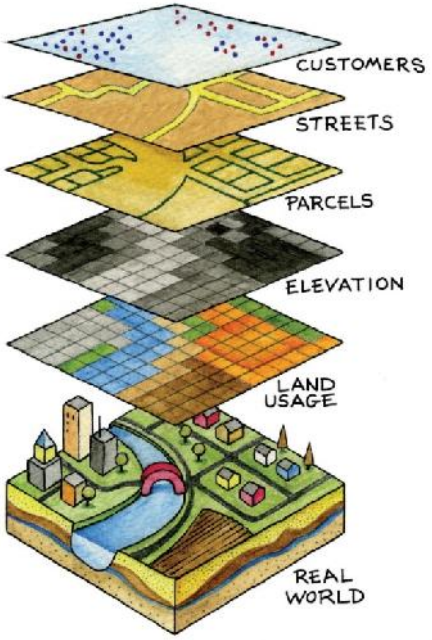
A geographic information system is a framework for understanding our world and applying geographic knowledge to solve problems and guide human behavior.

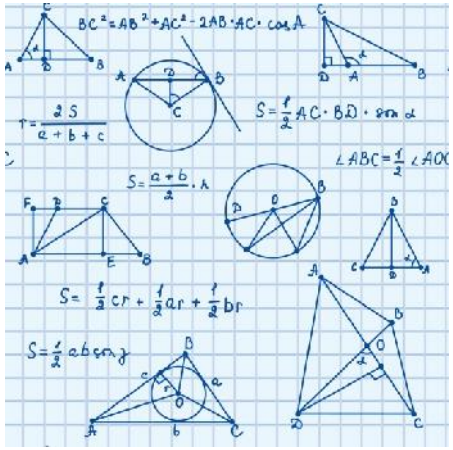


http://www.gislounge.com/the-components-of-gis-evolve/

HOW CAN GIS THINK?

Topology is a way of coding the geometry of spatial relationships inside the computer.





Map features + Data + Geometry/Topology

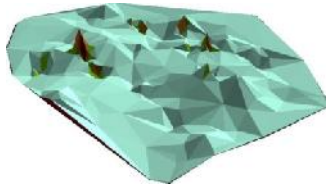
HOW IT WORKS…
MAP FEATURES AND DATA

- Points

- Lines

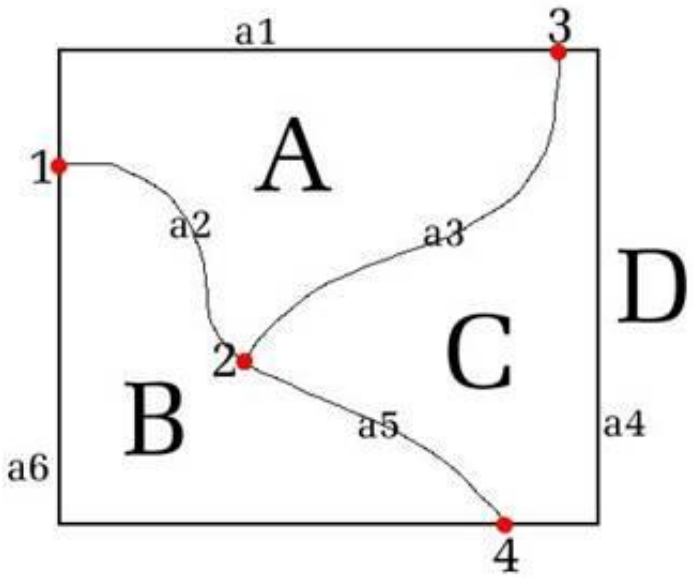
- Polygons

- Surfaces



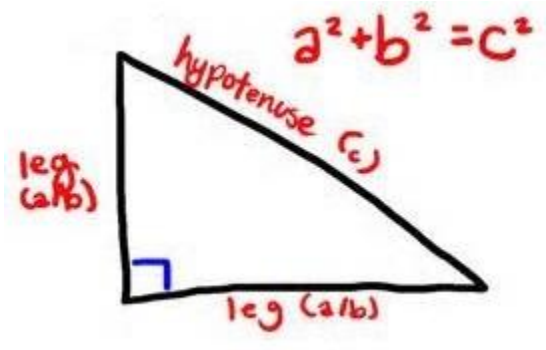
HOW IT WORKS… TOPOLOGY

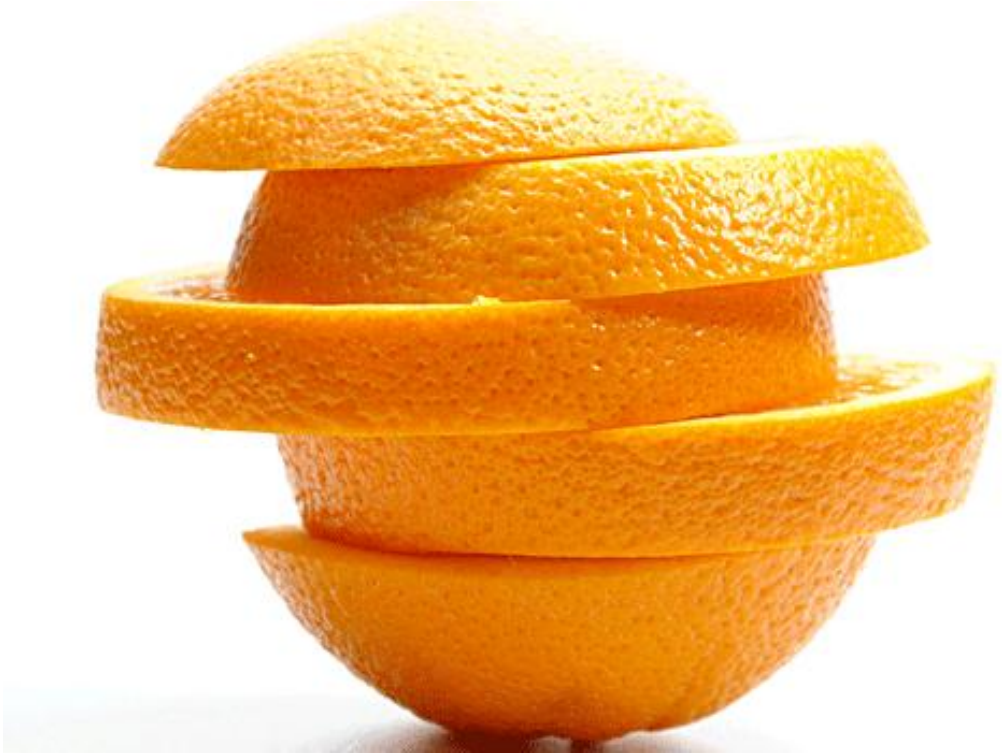
- Topology is the mathematics of neighborhood.
  - It is the information about how a shape relates to its neighboring objects.
- Three properties
  - What areas exist (Area)
  - How are they connected (Connectivity)
  - What is located to the left and right of the polygon (Contiguity)



HOW IT WORKS… GEOMETRY

- GIS uses geometry:
  - Pythagorean theorum
  - Interpolation
- To calculate 3D:
  - Slope
  - Volume
  - Flow
  - Structures

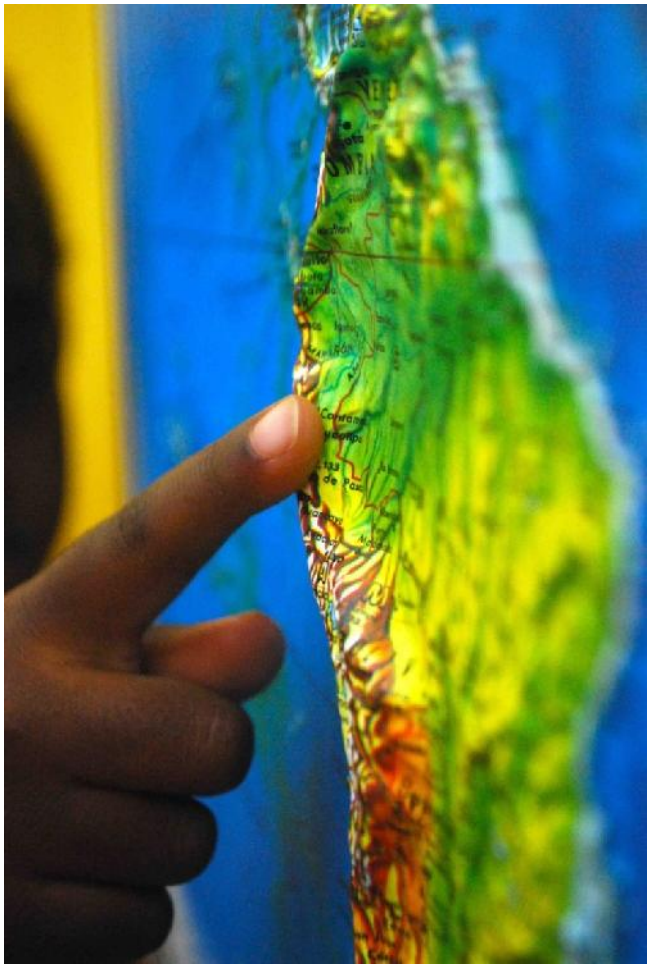




WHAT IS SO GREAT ABOUT GIS?

- Benefits
  - Enhanced visualization / communication
  - Increased efficiency
  - More informed decision making
  - Cost savings
  - Better management of resources
  - Democratization of data

- Encourages dialogue, observation, and critical thinking
  - What's going on in this map?
    What observations can you make?
  - What do you see that makes you say that?
    What's your evidence in the map?
  - What more can you find?



GOT GIS DATA?

80%
of all government information has a geospatial component

130,000+
is the number of geospatial datasets currently available on Data.gov to download for free

Growing
U.S. Bureau of Labor report that the geospatial sector has been growing by about 35% per year, with the commercial side growing at 100% per year.

TEST DRIVE: WHAT CAN GIS DO?

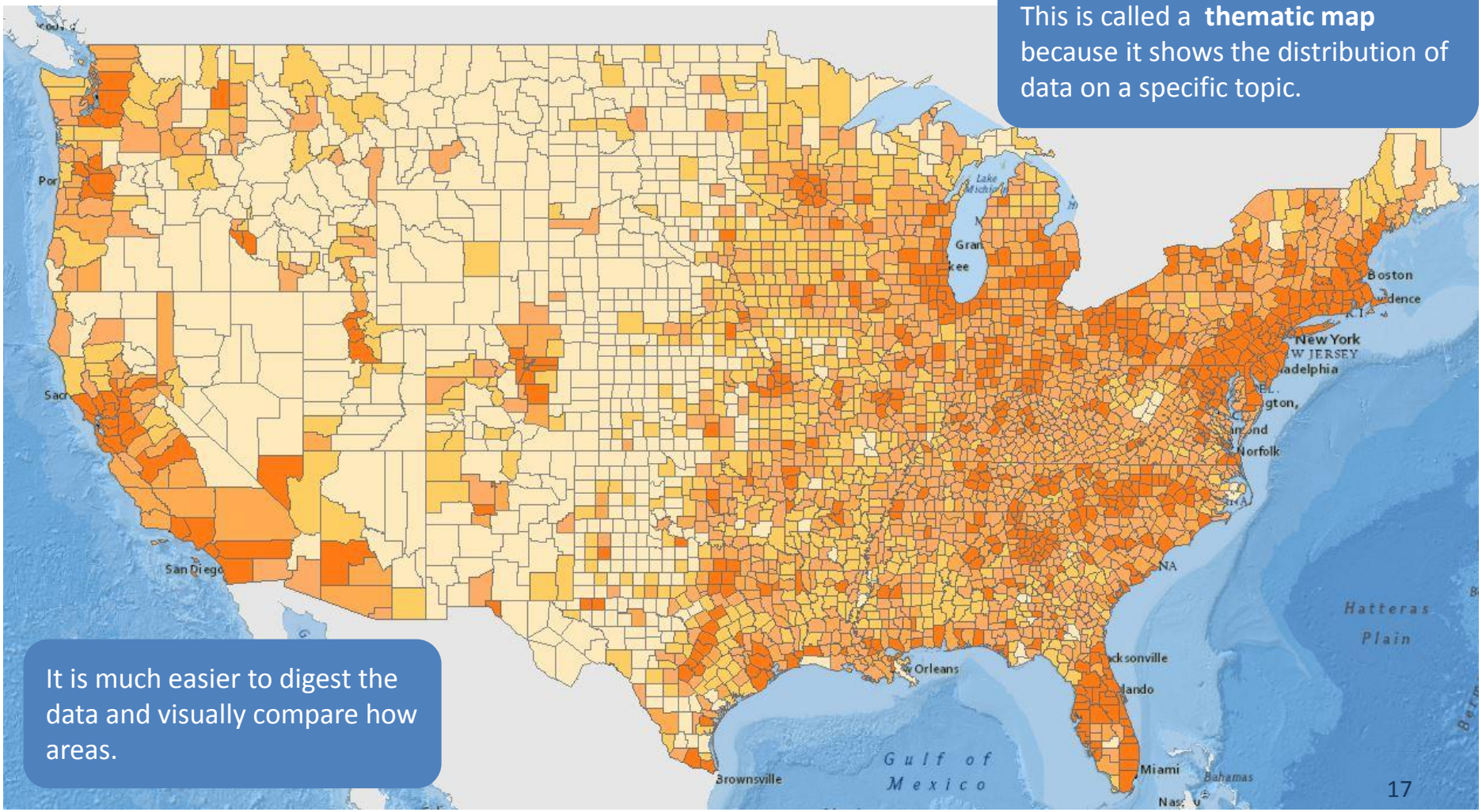
1.	Calculate directions and drive times	**NETWORK**	How do I get there? How long does it take?
2.	Locate physical features	**LOCATION**	Where is it?
3.	Visualize tabular data	**VISUALIZATION**	What does the data look like geographically?
4.	Measure distance in 2D	**DISTANCE**	How far is it?
5.	Overlay and find suitable locations	**OVERLAY**	Where is it suitable?
6.	Model scenarios and view in 3D	**MODEL**	What if? How does it look?
7.	Represent data in a abstract way	**ABSTRACT**	How can we look at this differently?
8.	Describe geographic distribution, patterns, clustering	**DISTRIBUTION**	How is the data distributed spatially? Is the data in a clustered, dispersed, or random pattern? Are clusters statistically significant hot spots, cold spots, or outliers?
9.	Show changes over time	**TRENDS**	What has changed?
10.	Model spatial relationships	**RELATIONSHIPS**	What is the relationship among features? Why? What is causing this?

VISUALIZE DATA: TABULAR (BEFORE)

NAME	STATE_NAME	STATE_FIPS	CNTY_FIPS	FIPS	POP2000	POP00_SQMI	WHITE	BLACK	AMERI_ES	ASIAN	HAWN_PI	OTHER	MULT_RACE	HISPANIC	MALES	FEMALES	AGE_UNDER5
Lake of the Woods	Minnesota	27	077	27077	4522	2.5	4396	13	51	11	0	5	46	29	2272	2250	188
Ferry	Washington	53	019	53019	7260	3.2	5480	15	1327	21	4	162	251	205	3764	3496	394
Stevens	Washington	53	065	53065	40066	15.8	36078	111	2266	193	66	271	1081	739	19940	20126	2425
Okanogan	Washington	53	047	53047	39564	7.4	29799	109	4537	176	28	3791	1124	5688	19706	19858	2493
Pend Oreille	Washington	53	051	53051	11732	8.2	10973	17	338	74	24	67	239	241	5881	5851	637
Boundary	Idaho	16	021	16021	9871	7.7	9401	16	199	57	7	85	106	335	4971	4900	687
Lincoln	Montana	30	053	30053	18837	5.1	18100	21	226	59	7	74	350	271	9542	9295	937
Flathead	Montana	30	029	30029	74471	14.2	71689	113	856	346	44	305	1118	1061	36911	37560	4415
Glacier	Montana	30	035	30035	13247	4.4	4693	11	8186	9	7	24	317	159	6553	6694	1075
Toole	Montana	30	101	30101	5267	2.7	4945	8	168	16	1	17	112	61	2716	2551	282
Liberty	Montana	30	051	30051	2158	1.5	2141	0	2	7	0	2	6	4	1063	1095	109
Hill	Montana	30	041	30041	16673	5.7	13263	15	2884	62	3	59	387	208	8306	8367	1190
Sheridan	Montana	30	091	30091	4105	2.4	3982	4	50	12	1	8	48	44	2039	2066	183
Divide	North Dakota	38	023	38023	2283	1.8	2260	0	3	12	0	4	4	14	1146	1137	70
Burke	North Dakota	38	013	38013	2242	2	2225	3	5	3	0	1	5	8	1130	1112	82
Renville	North Dakota	38	075	38075	2610	2.9	2551	6	17	12	0	3	21	19	1307	1303	113
Bottineau	North Dakota	38	009	38009	7149	4.2	6950	16	104	13	1	8	57	35	3600	3549	280
Rolette	North Dakota	38	079	38079	13674	14.6	3435	10	9983	10	0	16	220	110	6741	6933	1208
Towner	North Dakota	38	095	38095	2876	2.8	2799	2	59	2	0	1	13	5	1416	1460	137
Cavalier	North Dakota	38	019	38019	4831	3.2	4739	7	25	5	0	5	50	31	2402	2429	208
Pembina	North Dakota	38	067	38067	8585	7.7	8198	13	123	18	0	109	124	264	4305	4280	432
Kittson	Minnesota	27	069	27069	5285	4.8	5184	8	14	13	0	20	46	67	2621	2664	336
Roseau	Minnesota	27	135	27135	16338	9.7	15671	21	232	283	3	13	115	71	8367	7971	1185
Blaine	Montana	30	005	30005	7009	1.7	3685	12	3180	6	2	16	108	70	3460	3549	569
Phillips	Montana	30	071	30071	4601	0.9	4115	7	350	15	1	17	96	53	2305	2296	227
Valley	Montana	30	105	30105	7675	1.5	6765	10	723	19	1	20	137	60	3802	3873	422
Daniels	Montana	30	019	30019	2017	1.4	1937	0	26	5	2	12	35	32	988	1029	87
Whatcom	Washington	53	073	53073	166814	66.6	147485	1150	4709	4637	235	4159	4439	8687	82188	84626	10210
Bonner	Idaho	16	017	16017	36835	19.2	35574	40	322	101	17	155	626	604	18449	18386	2100
Ward	North Dakota	38	101	38101	58795	28.6	54327	1305	1215	483	36	428	1001	1125	29284	29511	4348
Koochiching	Minnesota	27	071	27071	14355	4.6	13798	27	309	25	9	11	176	81	7123	7232	779
Skagit	Washington	53	057	53057	102979	53.6	89070	450	1909	1538	163	7381	2468	11536	50982	51997	6718
Williams	North Dakota	38	105	38105	19761	9.2	18367	24	869	36	2	27	436	185	9687	10074	1135
McHenry	North Dakota	38	049	38049	5987	3.1	5911	5	24	2	0	3	42	24	3051	2936	294
St. Louis	Minnesota	27	137	27137	200528	29.7	190211	1704	4074	1333	54	451	2701	1597	98629	101899	10455
San Juan	Washington	53	055	53055	14077	22.7	13372	36	117	125	12	128	287	338	6860	7217	525
Roosevelt	Montana	30	085	30085	10620	4.5	4347	5	5921	46	5	27	269	131	5264	5356	858
Mountrail	North Dakota	38	061	38061	6631	3.4	4376	6	1988	14	3	17	227	87	3262	3369	431
Marshall	Minnesota	27	089	27089	10155	5.6	9873	10	29	17	0	165	61	298	5157	4998	583
Ramsey	North Dakota	38	071	38071	12066	9.3	11138	25	651	31	3	20	198	63	5954	6112	682
Walsh	North Dakota	38	099	38099	12389	9.6	11752	41	126	24	2	311	133	700	6196	6193	711
Beltrami	Minnesota	27	007	27007	39650	13	30394	142	8071	225	8	82	728	394	19557	20093	2825
Pierce	North Dakota	38	069	38069	4675	4.3	4605	5	32	12	0	2	19	28	2297	2378	246
Chelan	Washington	53	007	53007	66616	22.3	55711	172	661	451	77	8121	1423	12831	33158	33458	4750
Pondera	Montana	30	073	30073	6424	3.9	5374	6	929	9	3	8	95	54	3169	3255	398
Clallam	Washington	53	009	53009	64525	24.2	57505	545	3303	731	104	761	1576	2203	32054	32471	3313

3 VISUALIZE DATA: NOW ON A MAP

Population per square mile

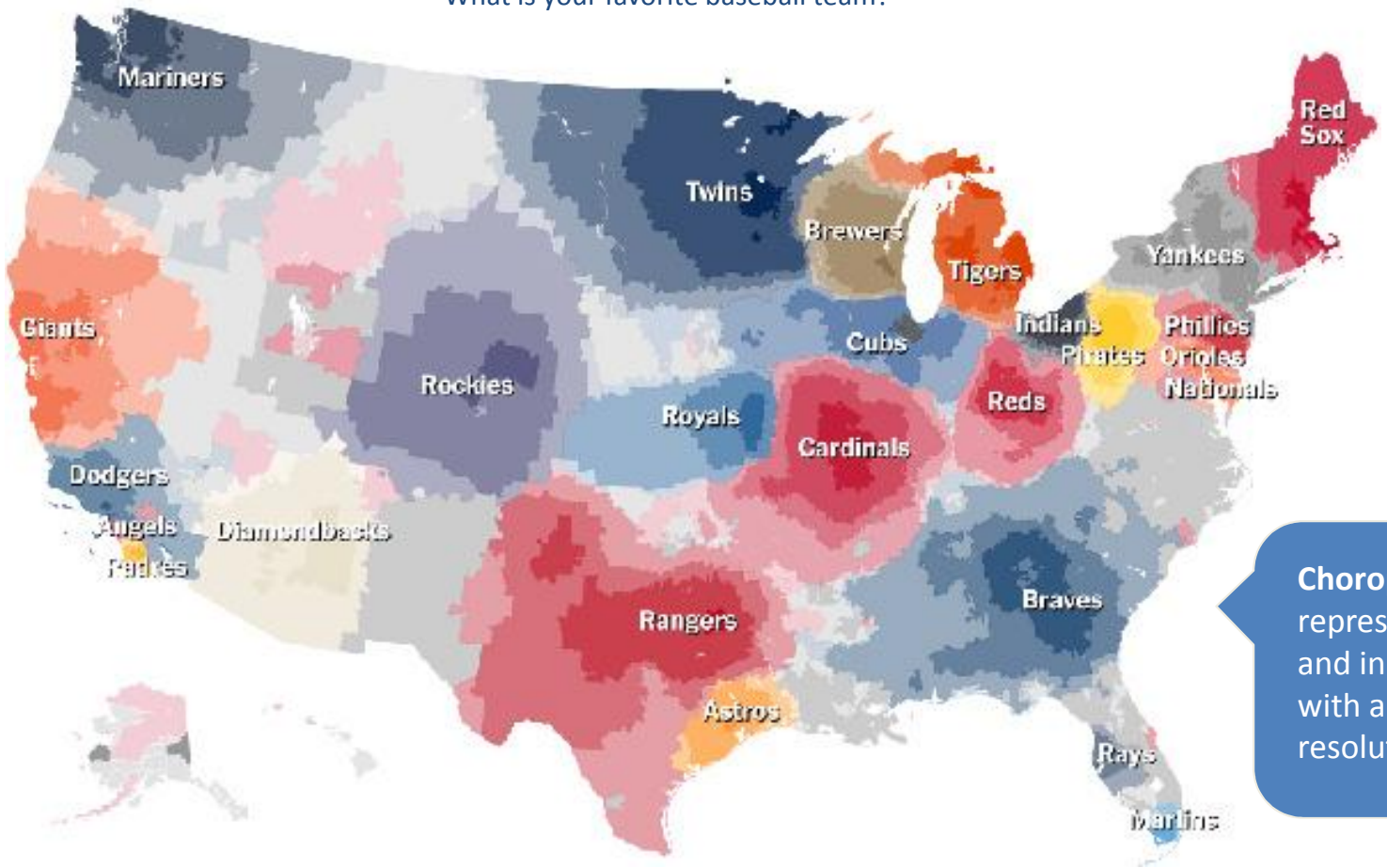


This is called a **thematic map** because it shows the distribution of data on a specific topic.

It is much easier to digest the data and visually compare how areas.

VISUALIZE DATA: NOMINAL

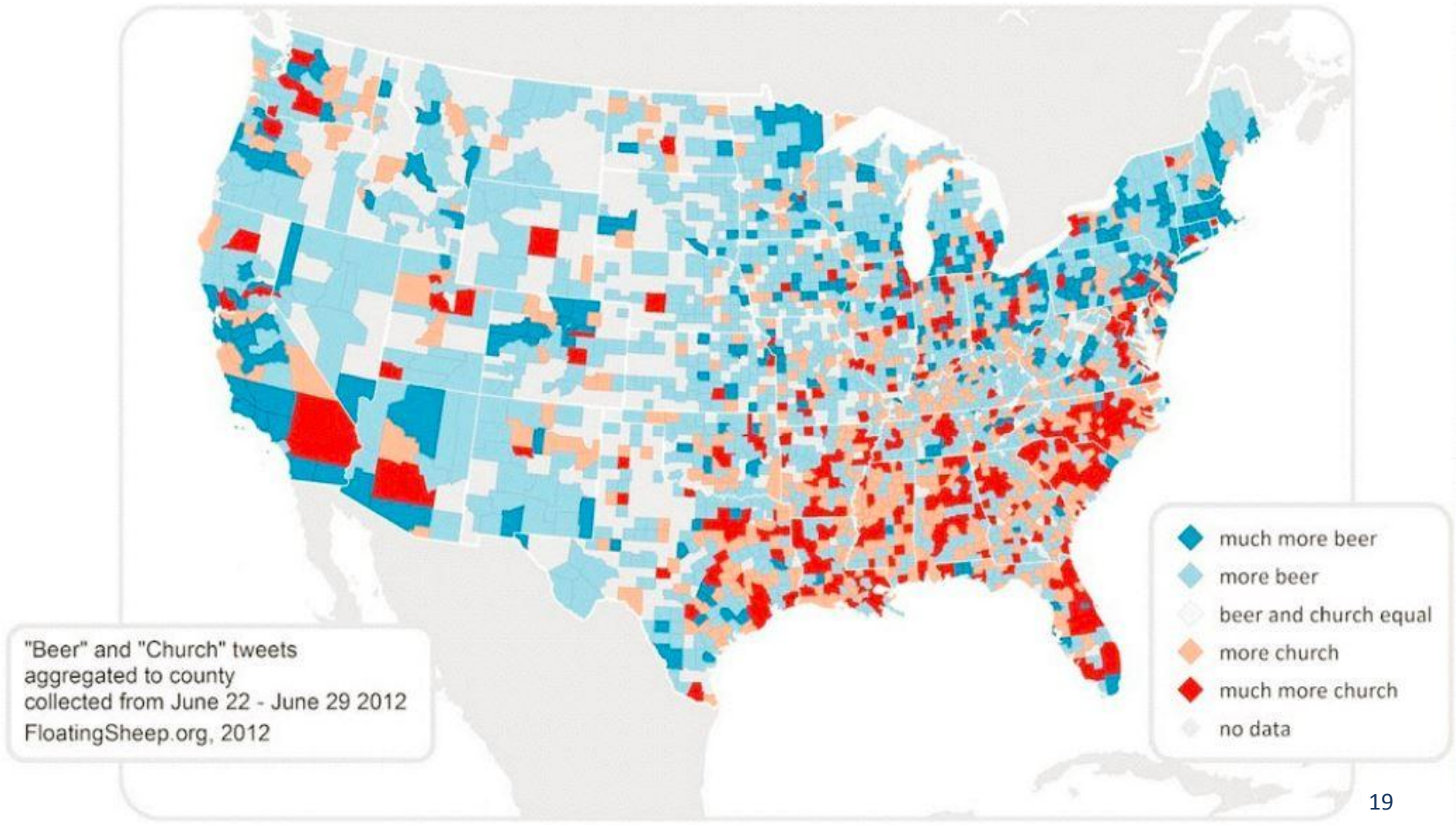
What is your favorite baseball team?



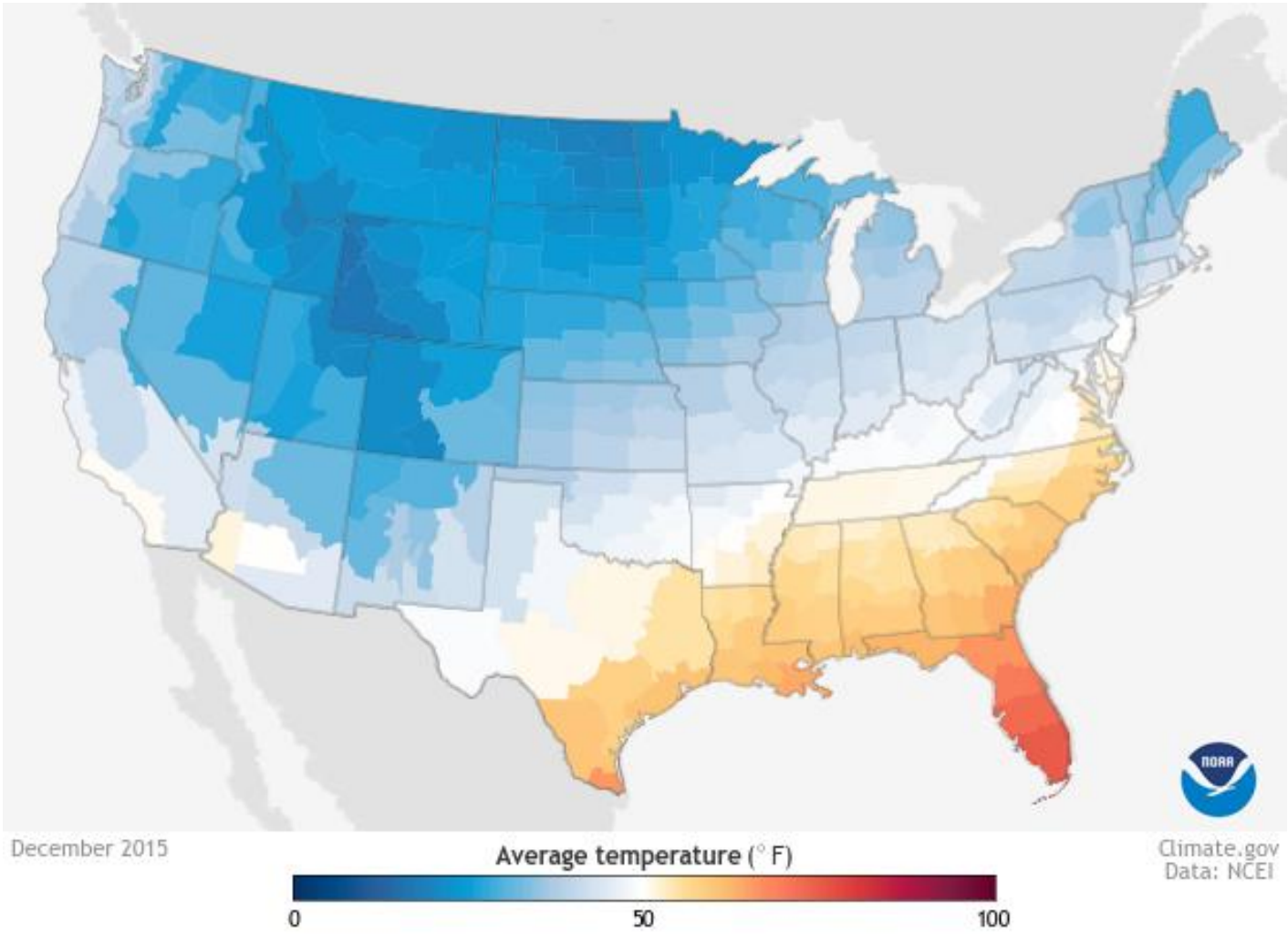
Choropleth maps can represent nominal data and in this case it has with a higher spatial resolution (ZIP code).

Source: New York Times, http://learning.blogs.nytimes.com/2014/04/29/baseball-happiness-and-immigration-exploring-american-society-and-history-with-new-york-times-maps/?_php=true&_type=blogs&_r=0

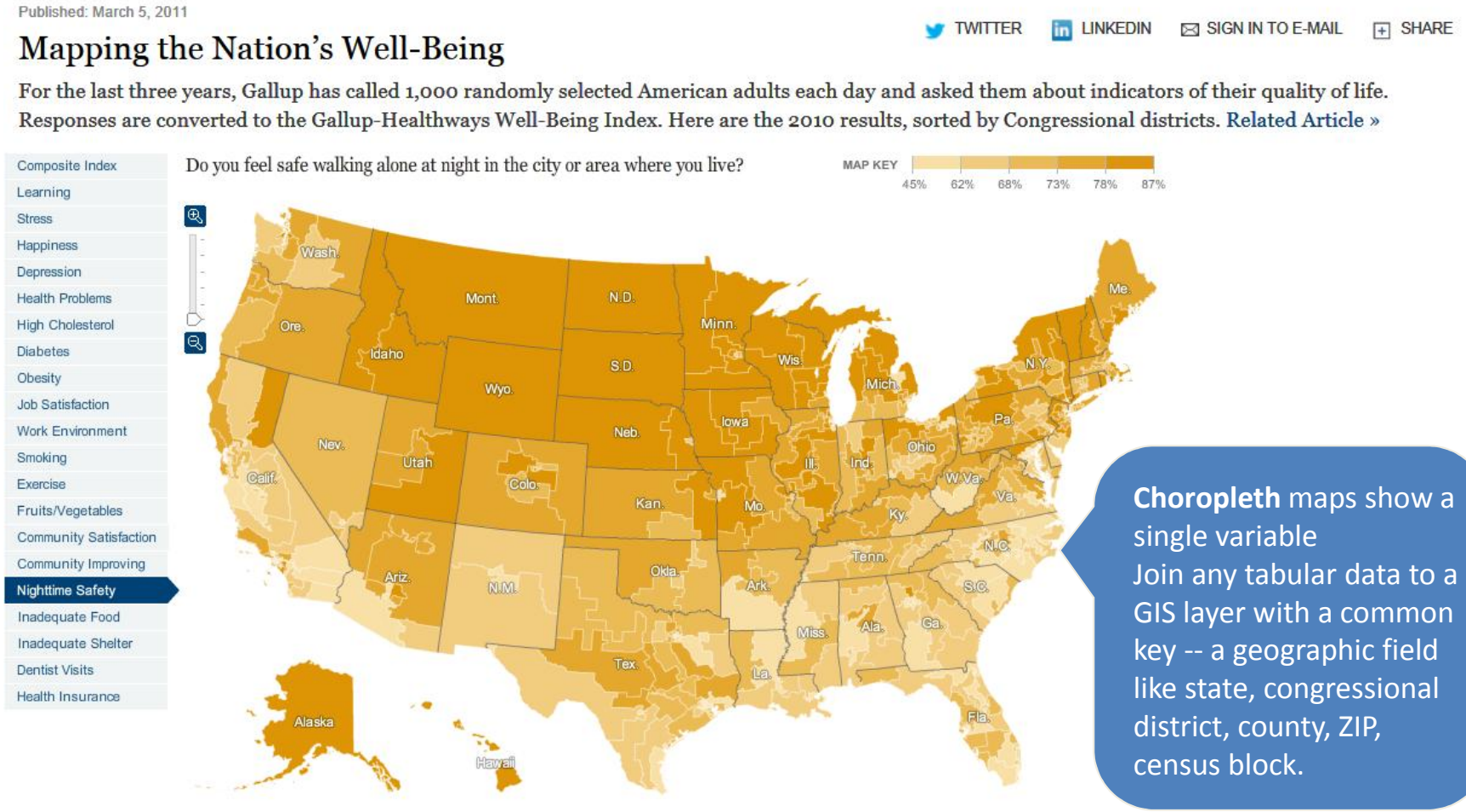
VISUALIZE DATA: ORDINAL



VISUALIZE DATA: INTERVAL



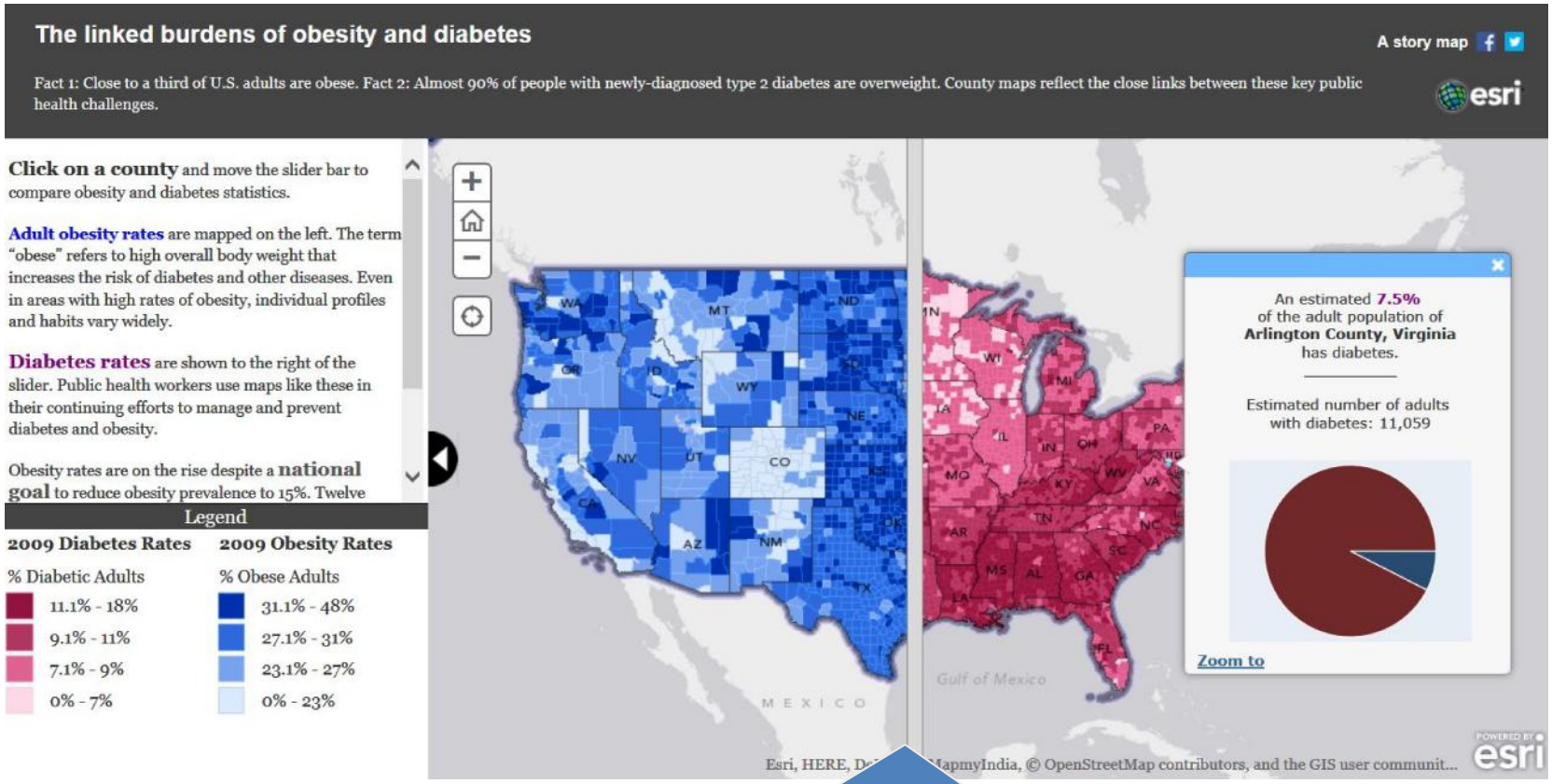
VISUALIZE DATA: RATIO



Choropleth maps show a single variable
Join any tabular data to a GIS layer with a common key -- a geographic field like state, congressional district, county, ZIP, census block.

Source: New York Times, http://www.nytimes.com/interactive/2011/03/06/weekinreview/20110306-happiness.html

VISUALIZE DATA: MULTI-LAYER



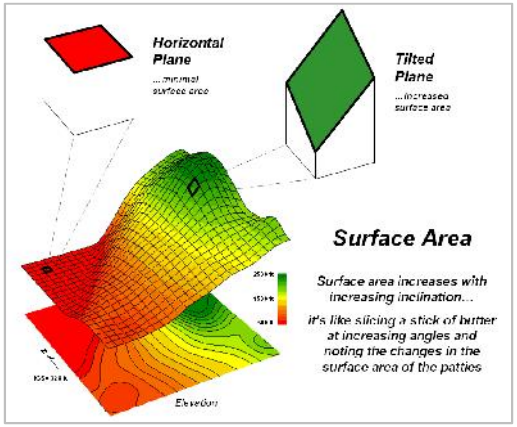
Overlays and slider
Good for comparing layers and showing possible links between layers.

Source: Esri Story Maps
http://storymaps.esri.com/stories/diabetes/

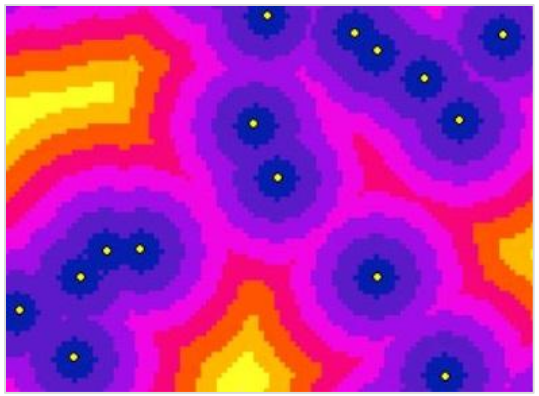
MEASURE DISTANCE IN 2D

Euclidean Distance (green)
Manahattan Distance (blue)

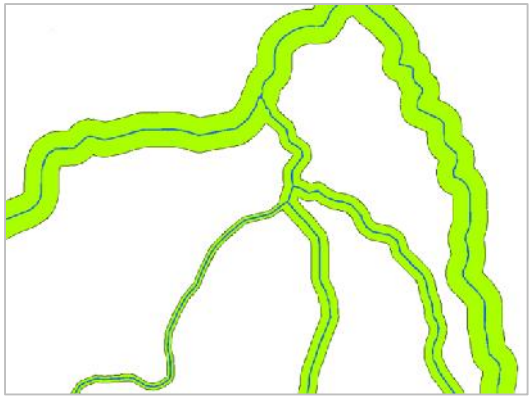
Area



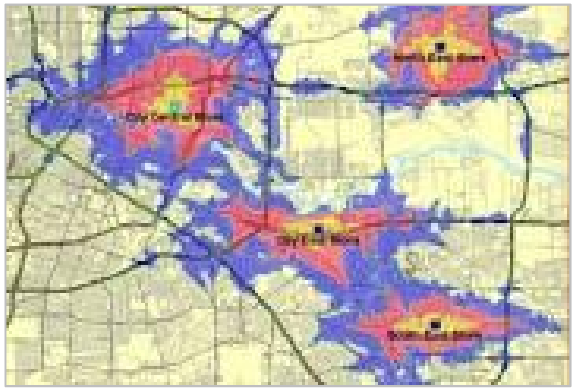
Euclidean Distance Buffers



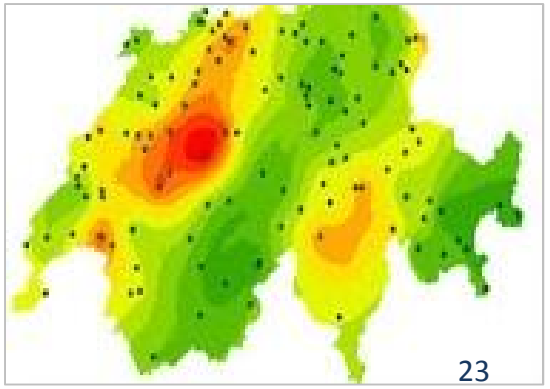
Variable Buffers



Drive time / Service areas



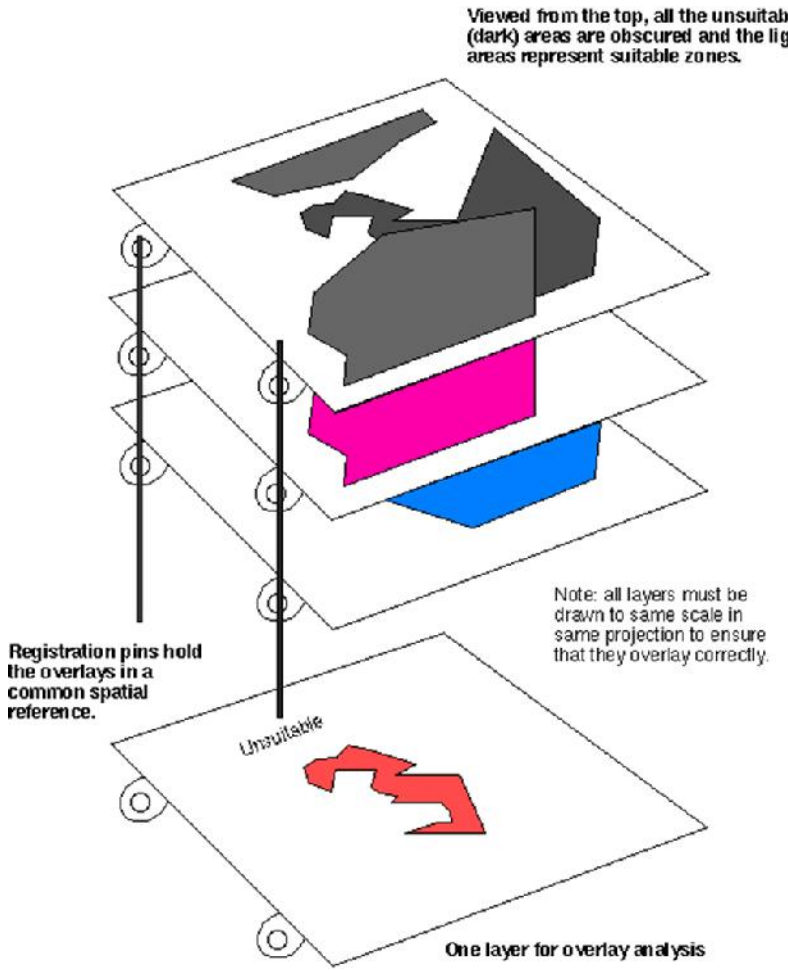
Interpolation of sample points across a surface



5 OVERLAY AND FIND SUITABLE LOCATIONS

- Where can I find a house?
  - With 4 bedrooms (attributes)
  - On one acre of land (area)
  - Within a 15-minute walk to a grocery store (network distance)
  - Within public schools that exceed state standards (contained within)
  - Within 1 mile of a stream or park (euclidean buffer)

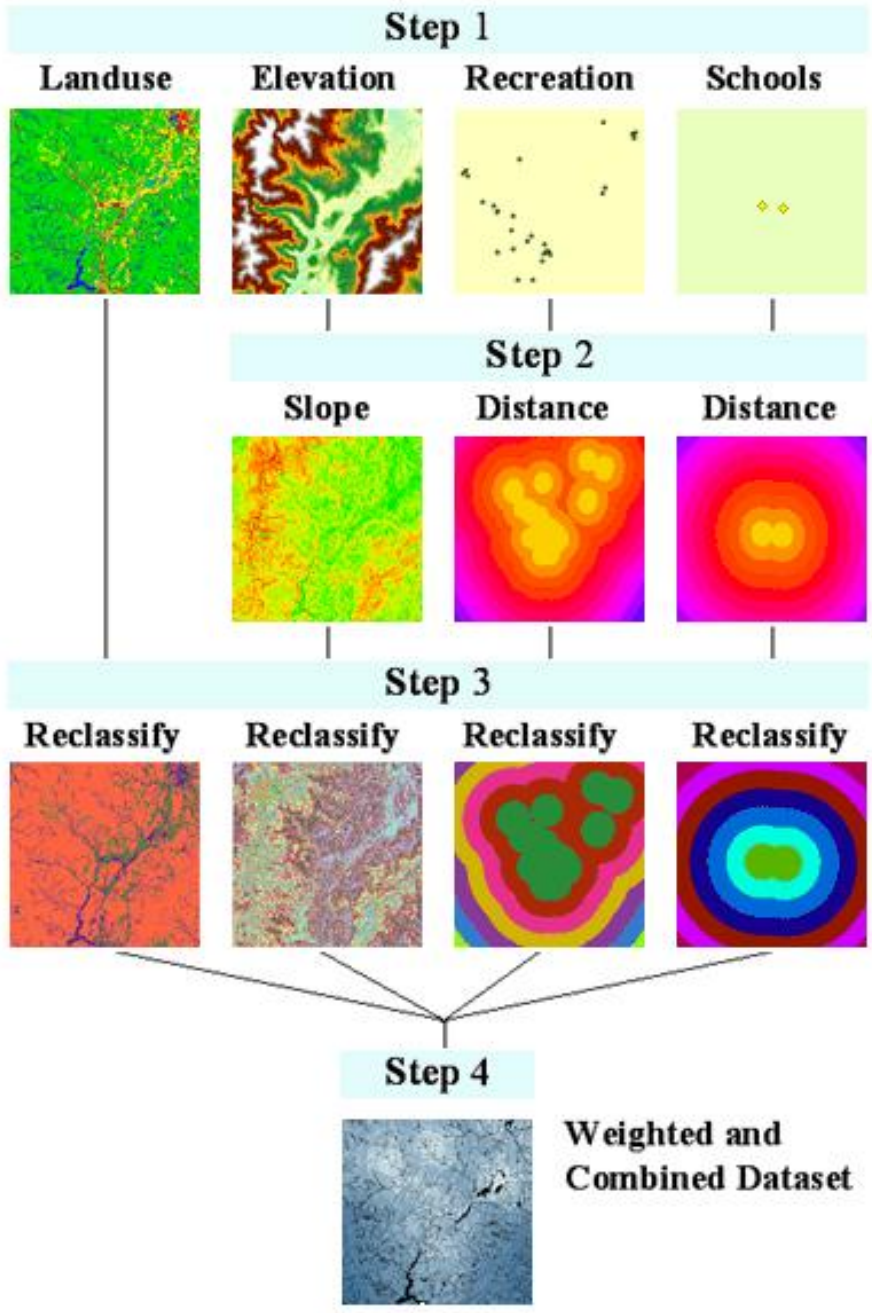
- Where is a suitable sites to construct a new school?
  - Forest and agriculture better than residential housing
  - Flat slopes
  - Near recreation sites
  - Far from existing schools



5

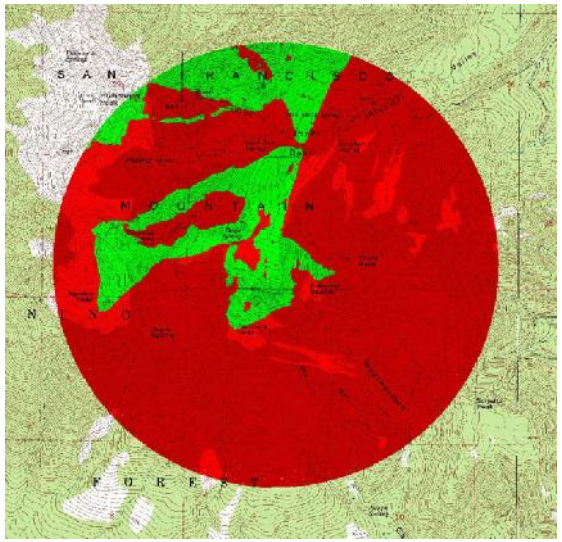
OVERLAY AND FIND SUITABLE LOCATIONS

GIS enables you to analyze spatially and overlay layers to find a suitable site.

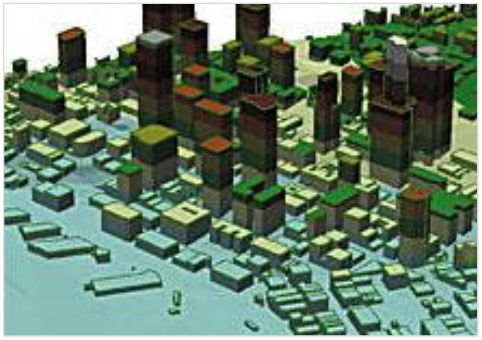


6 MODEL SCENARIOS AND VIEW IN 3D

- Volume
- Flow

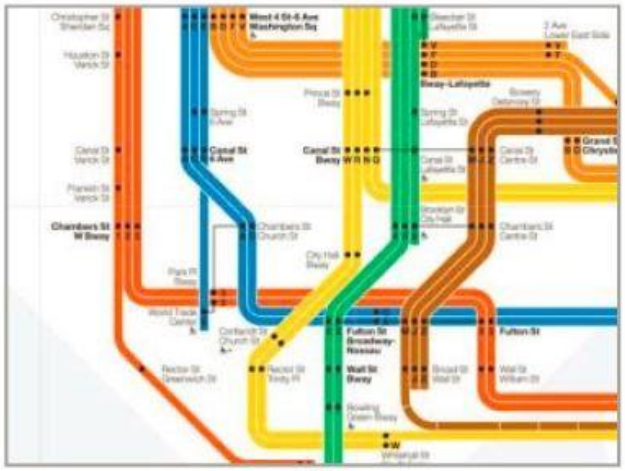


- Viewsheds
- Wave propagation
- Projectile range



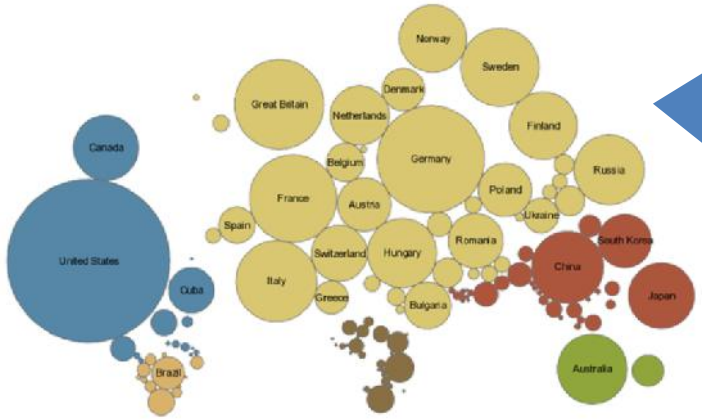
- 3D buildings
- Extruded structures

7 REPRESENT DATA IN A ABSTRACT WAY



Sometimes an **abstract or distorted version** is easier to understand than a realistic one. Here only the connections and stations matter.

http://web.mit.edu/rruth/www/Papers/RosenholtzSPIE2011.pdf



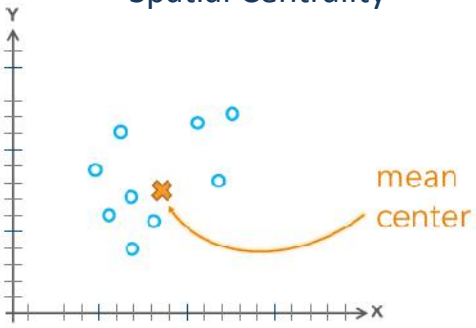
A **cartogram** is a map in which some variable (here all time Olympic Medals) is substituted for land area.

Cartogram from Esri http://www.arcgis.com/home/item.html?id=fa51d73a98aa4dd4964dba8b42958704

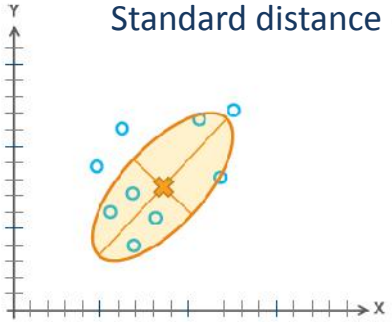
8 DESCRIBE GEOGRAPHIC DISTRIBUTION, PATTERNS, AND CLUSTERING

The descriptive spatial statistics extend what the eyes and mind do intuitively and help summarize and describe a set of data. They are useful to compare two sets of data.

Spatial Centrality



Spatial Dispersion:
Standard distance deviation



Spatial Homogeneity

Spatial Autocorrelation

Does one layer depend on the other?

SHOW CHANGES OVER TIME

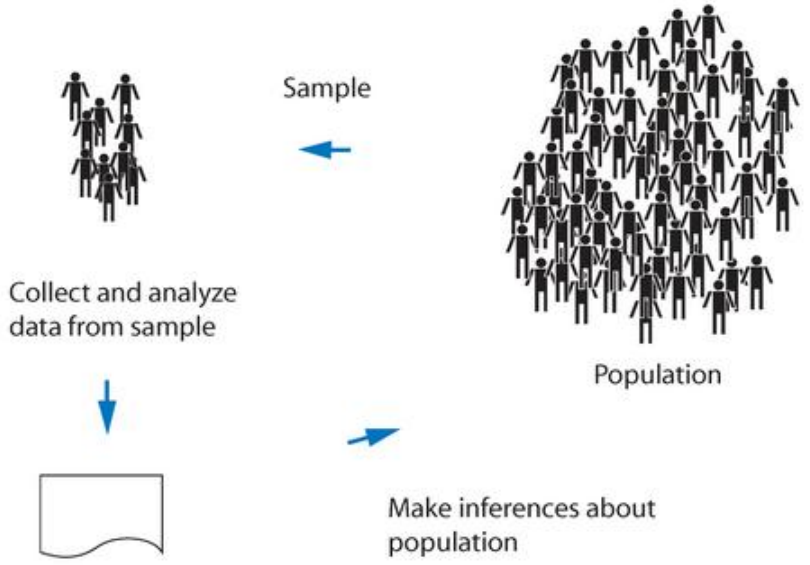
- Time series animation
  - Video or slider control
- Change in mean center
  - Where is the population center changing over time?

http://www.census.gov/dataviz/visualizations/050/

MODEL SPATIAL RELATIONSHIPS

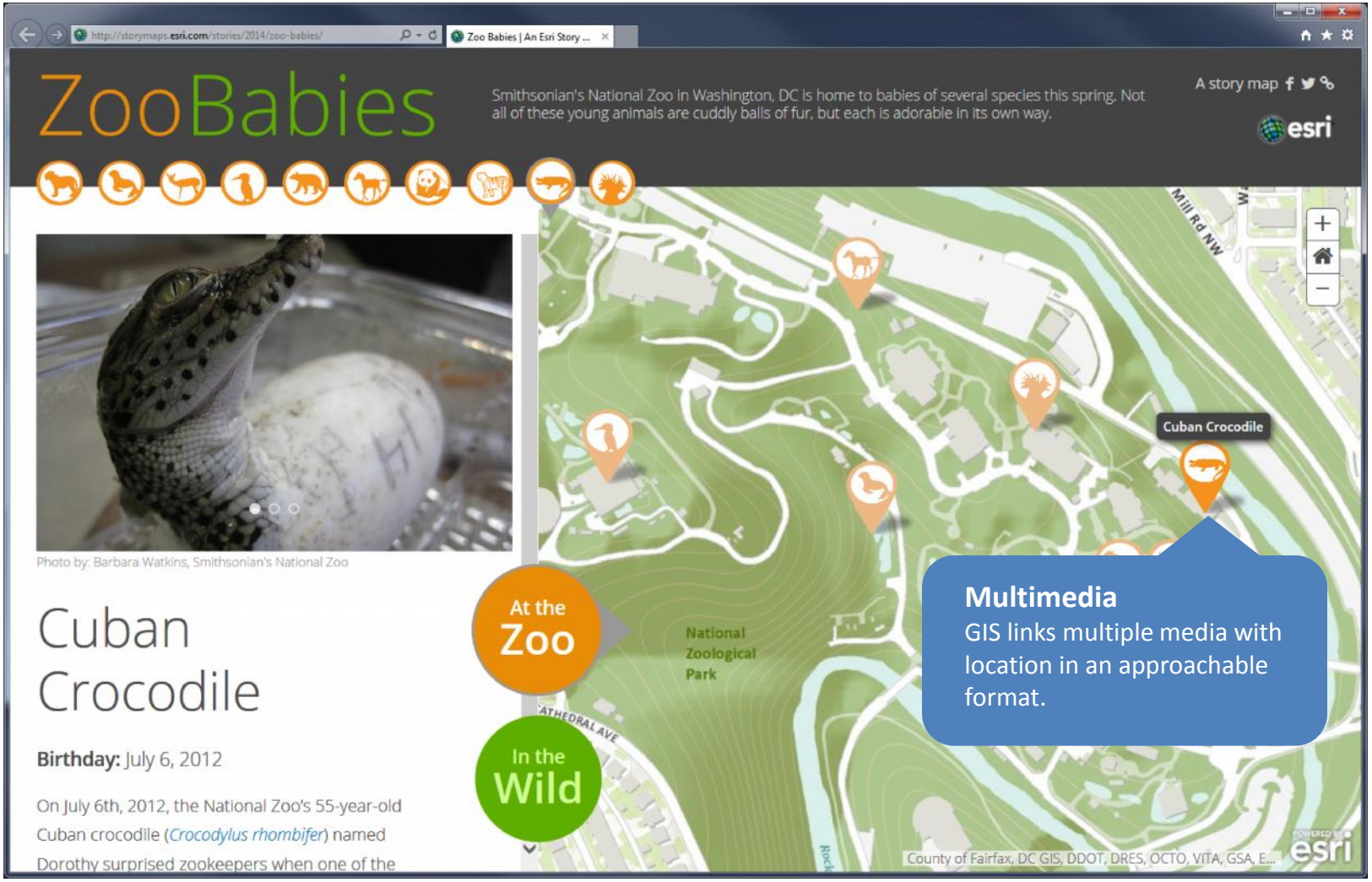
- Inferential spatial statistics attempt to explain why.
  - Infer from samples to a population
  - What is causing this relationship between layers?

- Methods:
  - Exploratory Regression
  - Generate Network Spatial Weights
  - Generate Spatial Weights Matrix
  - Geographically weighted regression
  - Ordinary Least Squares



http://www.spatialanalysisonline.com/HTML/?statistical_inference.htm

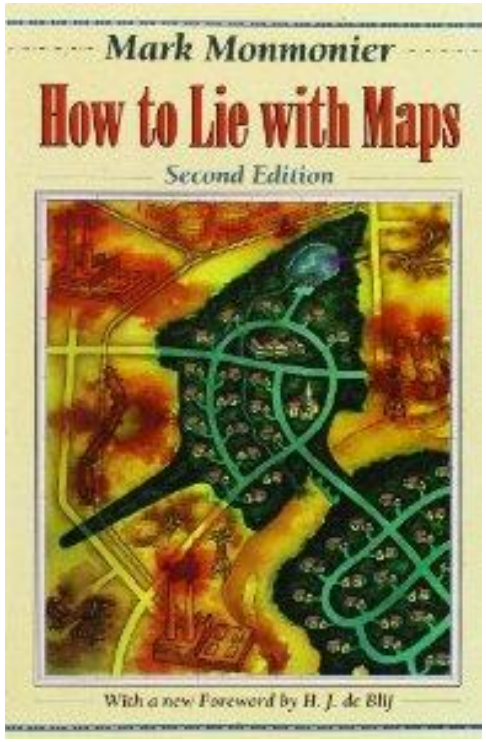
INTEGRATE MEDIA



THE ART OF GEOSPATIAL VISUALIZATIONS

It's not just software and it's not always as simple as "just the facts"; it's thinking through what the data (and you) want to communicate.

- Perception
  - Story
  - Manipulation
  - Deception
  - Projection
  - Break points
  - Color
- Rubric
  - Digestibility
  - Clarity
  - Questions prompted
  - Message delivered



GIS FUNCTIONALITY TAKEAWAYS

- GIS can integrate tabular data (from a spreadsheet, database, surveys, social media, etc.) with locational information (country, state, county, ZIP, etc.) to make data become more visual, digestible, and meaningful.
- GIS can help think through any problem where location matters.
- GIS can compare different areas, time, or populations.
- GIS represent data in ways that improve understanding.
- GIS can provide the spatial backbone to integrate media (photos, narrative, video, audio).
- GIS can help describe and compare data.
- GIS can help model a larger population, infer, predict, and explain.
- GIS can affect people's perceptions and public policy.