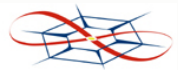
Overview of Geographic Information Systems (GIS)

John Kostelnick

Department of Geography/ITTC

University of Kansas



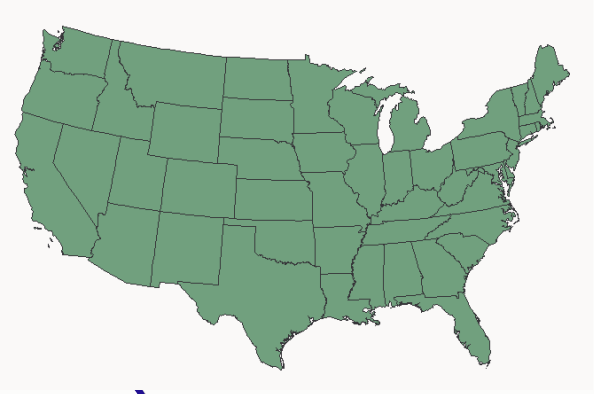
PRISM

Topics

- What is GIS?
- What can you do with GIS?
- How does GIS work?
- GIS and PRISM Project

What is GIS?

- **G**eographic
  Information
  Systems



- "G" is for Geography (or Maps)
  - *Geography* = the study of the spatial distribution of things on the Earth. Geography deals with place and "where" things are located.
  - Maps are essential tools for geographers

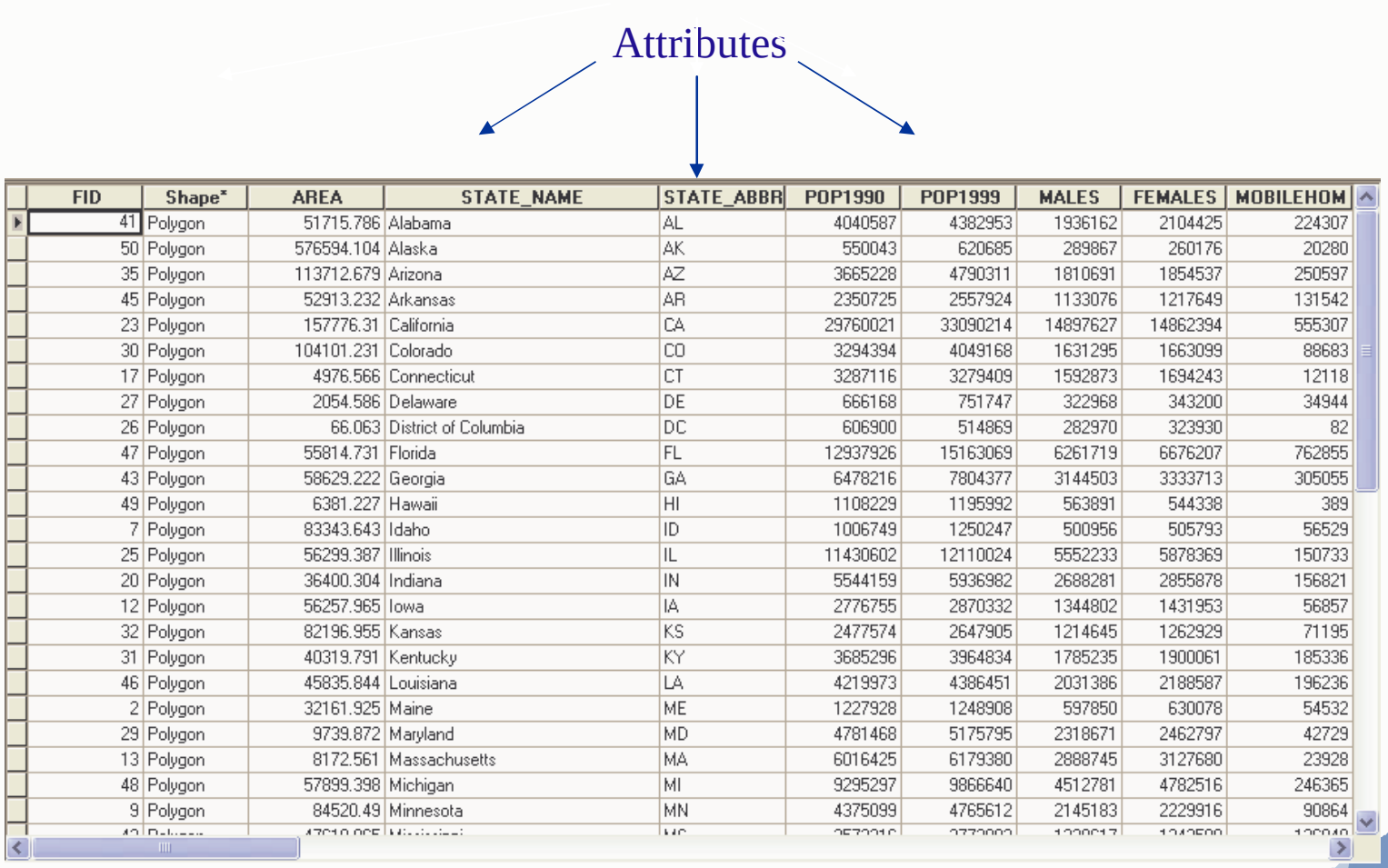
What is GIS?

- "I" is for Information (or Attribute Data)
  - Information or attribute data stored in a database and an attribute table
  - Information or attribute data have a spatial aspect
  - Information or attribute data allows for analysis, a key feature of GIS

What is GIS?

- "I" is for Information (or Attribute Data)
  - Several attributes stored in the database or attribute table
  - *Attribute* = characteristic of a geographic feature (e.g., state, river, city) that has a value
  - E.g., Attributes for a road may include…
    - Name (Interstate 35)
    - Speed limit (70 mph)
    - Surface type (paved)

Example of an Attribute Table

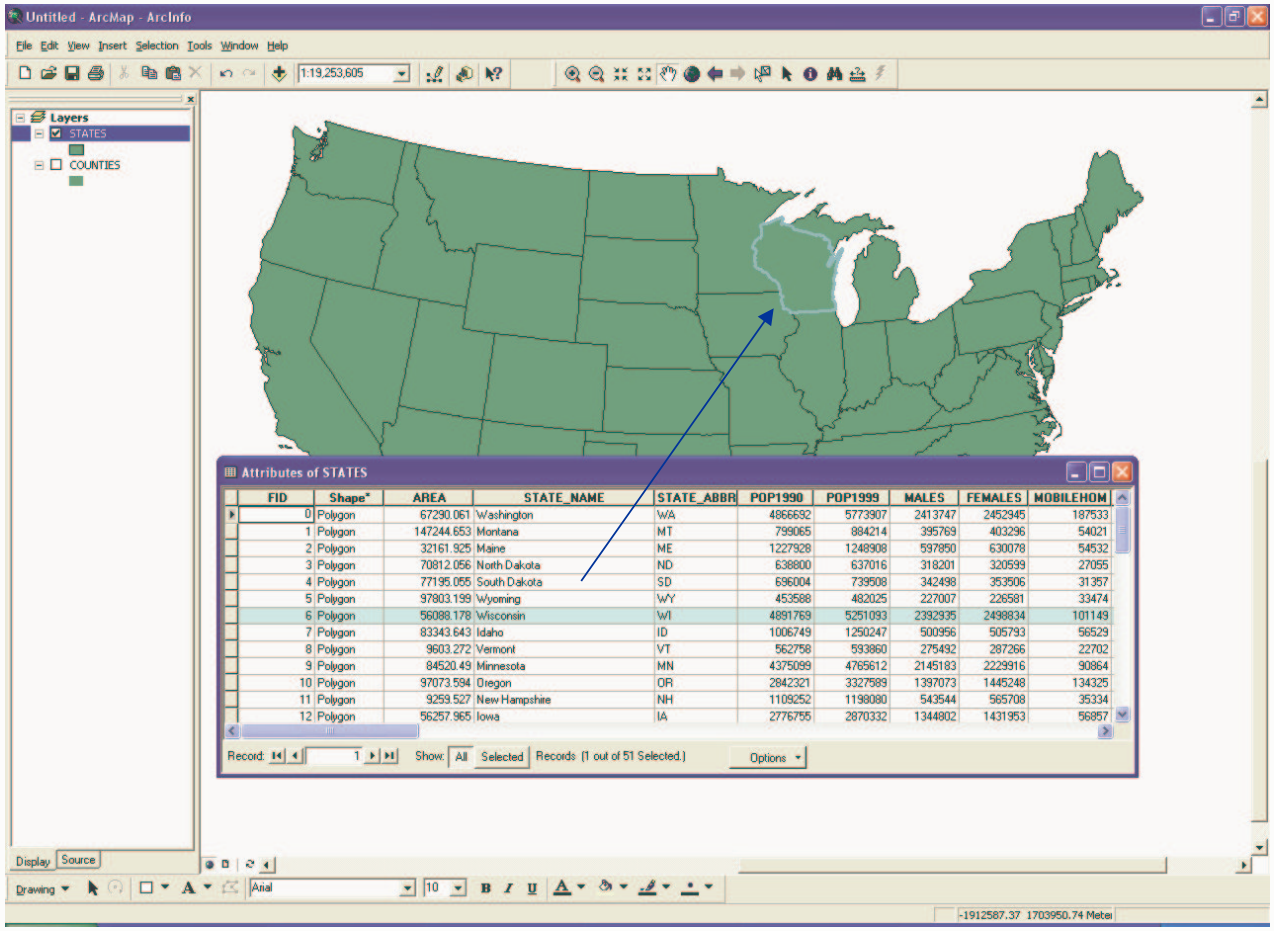


FID	Shape*	AREA	STATE_NAME	STATE_ABBR	POP1990	POP1999	MALES	FEMALES	MOBILEHOM
41	Polygon	51715.786	Alabama	AL	4040587	4382953	1936162	2104425	224307
50	Polygon	576594.104	Alaska	AK	550043	620685	289867	260176	20280
35	Polygon	113712.679	Arizona	AZ	3665228	4790311	1810691	1854537	250597
45	Polygon	52913.232	Arkansas	AR	2350725	2557924	1133076	1217649	131542
23	Polygon	157776.31	California	CA	29760021	33090214	14897627	14862394	555307
30	Polygon	104101.231	Colorado	CO	3294394	4049168	1631295	1663099	88683
17	Polygon	4976.566	Connecticut	CT	3287116	3279409	1592873	1694243	12118
27	Polygon	2054.586	Delaware	DE	666168	751747	322968	343200	34944
26	Polygon	66.063	District of Columbia	DC	606900	514869	282970	323930	82
47	Polygon	55814.731	Florida	FL	12937926	15163069	6261719	6676207	762855
43	Polygon	58629.222	Georgia	GA	6478216	7804377	3144503	3333713	305055
49	Polygon	6381.227	Hawaii	HI	1108229	1195992	563891	544338	389
7	Polygon	83343.643	Idaho	ID	1006749	1250247	500956	505793	56529
25	Polygon	56299.387	Illinois	IL	11430602	12110024	5552233	5878369	150733
20	Polygon	36400.304	Indiana	IN	5544159	5936982	2688281	2855878	156821
12	Polygon	56257.965	Iowa	IA	2776755	2870332	1344802	1431953	56857
32	Polygon	82196.955	Kansas	KS	2477574	2647905	1214645	1262929	71195
31	Polygon	40319.791	Kentucky	KY	3685296	3964834	1785235	1900061	185336
46	Polygon	45835.844	Louisiana	LA	4219973	4386451	2031386	2188587	196236
2	Polygon	32161.925	Maine	ME	1227928	1248908	597850	630078	54532
29	Polygon	9739.872	Maryland	MD	4781468	5175795	2318671	2462797	42729
13	Polygon	8172.561	Massachusetts	MA	6016425	6179380	2888745	3127680	23928
48	Polygon	57899.398	Michigan	MI	9295297	9866640	4512781	4782516	246365
9	Polygon	84520.49	Minnesota	MN	4375099	4765612	2145183	2229916	90864

What is GIS?

- "S" is for System
  - System brings it all together, links the geography (maps) with the information (attributes)
  - System includes:
    - Hardware = computer, printer, plotter, scanner, etc.
    - Software = GIS software (E.g., ESRI's ArcGIS)
    - GIS users

Linking the Map with the Database



PRISM

What is GIS?

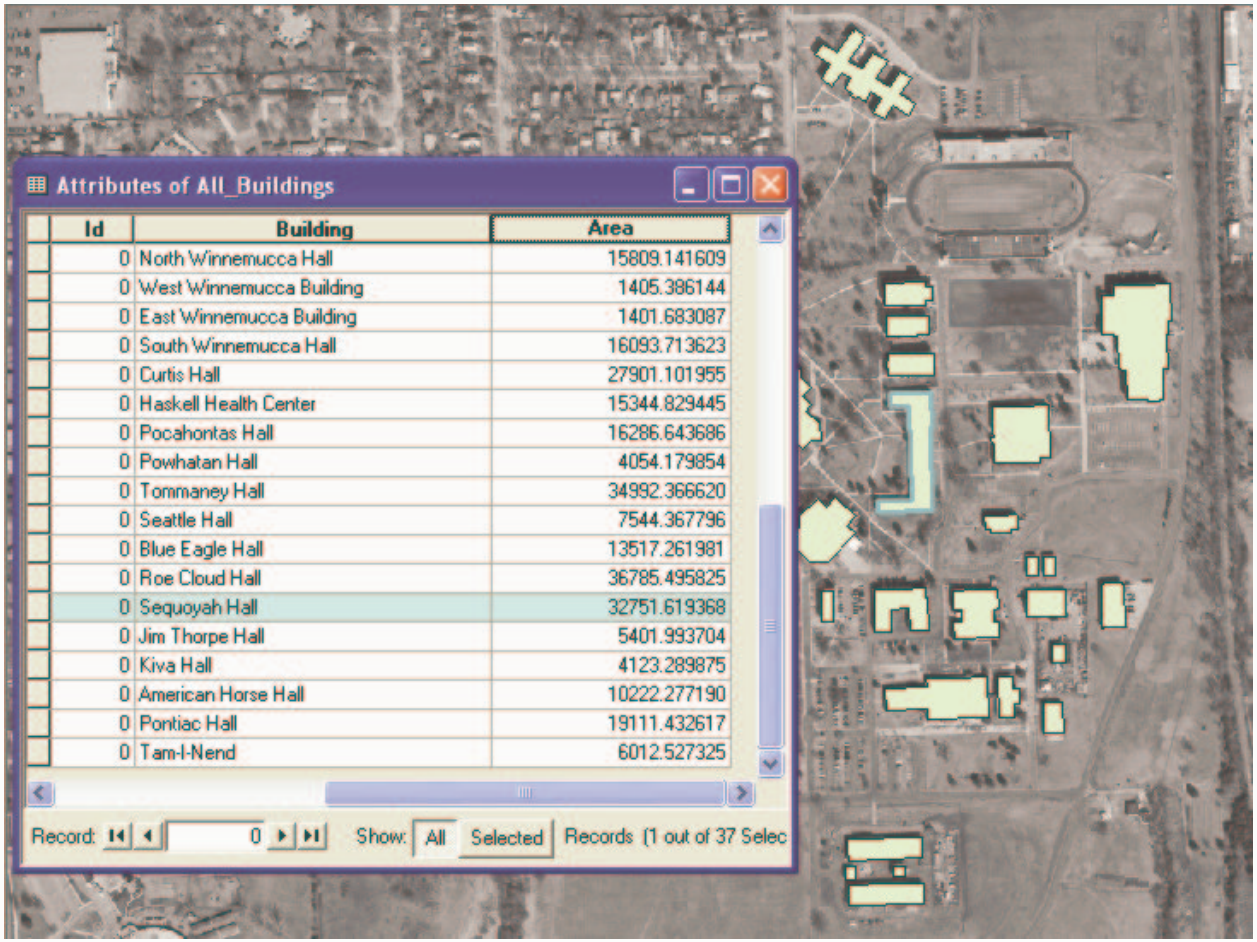
- Summary
  - GIS is a mix of geography, cartography (mapmaking), computer science
  - GIS allows us to address problems or questions that have a geographic or spatial aspect
  - Several problems in science have geographic aspects which can be addressed with GIS

What Can You Do with GIS?

- A Few Examples of GIS Applications
  - Inventorying and Mapping Resources
  - Calculating Areas and Distances
  - Site Suitability
  - Emergency Response
  - Species Habitat Modeling
  - 3-D Visualization

Inventory of Fire Hydrants on Haskell Campus

Calculating Area of Haskell Buildings

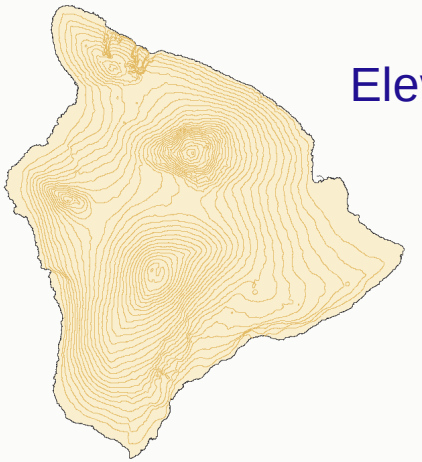


PRISM

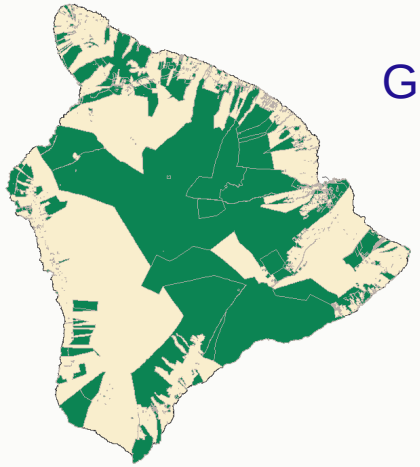
Finding Suitable Sites for a Radio Tower

- Find all sites that meet the following:
  - Elevation of at least 3000 feet
  - State owned lands that are not protected
  - Area of at least 1-square kilometer
  - Within 3 kilometers of a major road

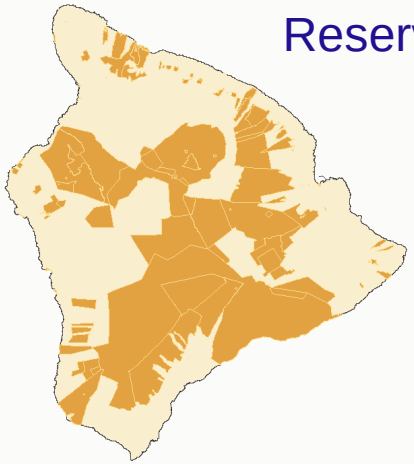
Finding Suitable Sites for a Radio Tower



Elevation



Government Lands



Reserve Lands

Major Roads

PRISM

Finding Suitable Sites for a Radio Tower

Suitable Sites

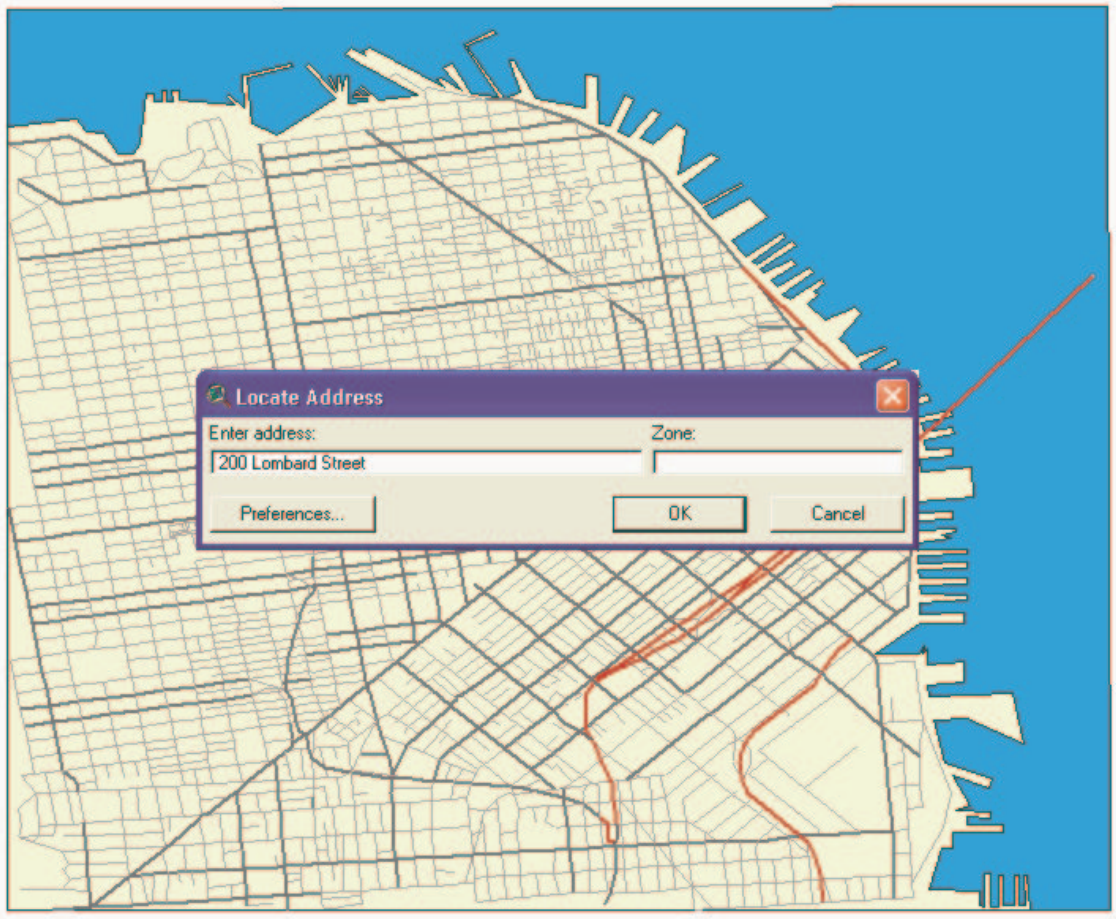
Emergency Response

- A common geographic problem in emergency response:

  What is the fastest route for an ambulance to travel from a hospital to an accident scene?

Map Layer of San Francisco Streets

Locating the Accident Scene



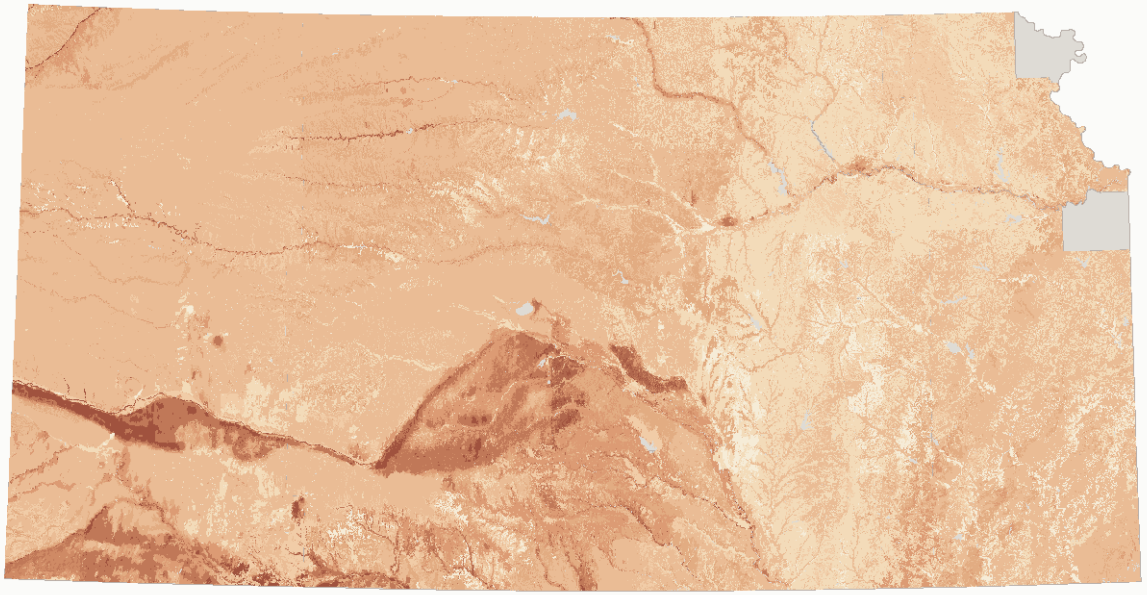
Map Layer of Hospitals

GIS calculates the fastest route from the hospital to the accident scene

Modeling Prairie Dog Habitats in Kansas

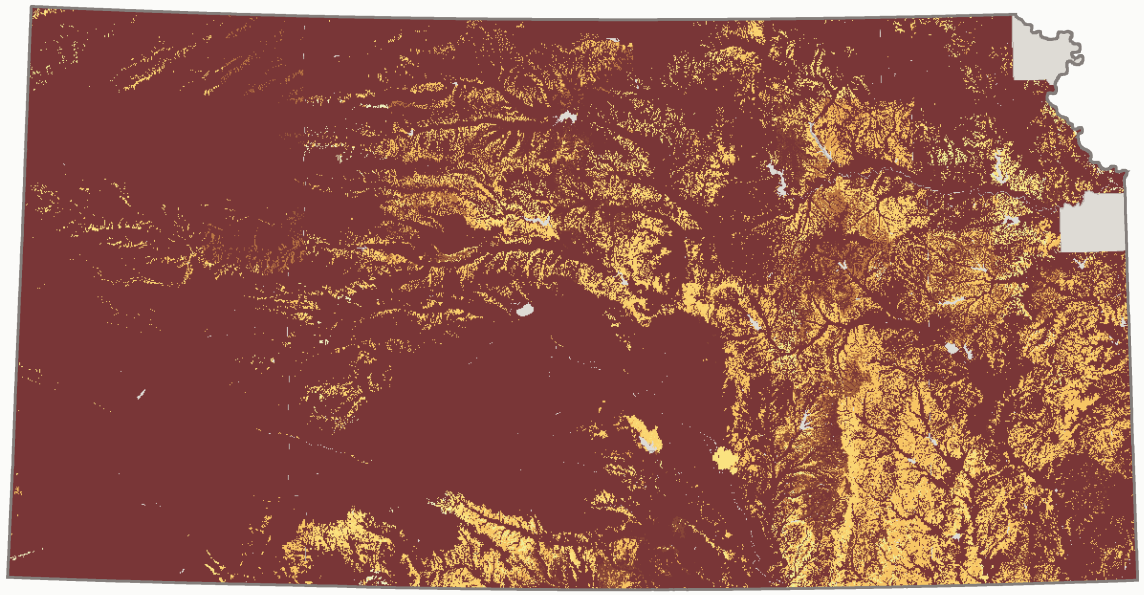
- GIS can be used for modeling, including habitat modeling
- Where are the ideal habitats for prairie dogs in Kansas?
- 4 Important Variables:
  - Soil Texture
  - Soil Depth
  - Slope
  - Landcover

Soil Texture



Soil Texture (1 = Clay, 20 = Sand)

Soil Depth to Bedrock



Soil Depth to Bedrock (inches)

0 - 6
7 - 12
13 - 18
19 - 24
25 - 30
31 - 36
37 - 42
43 - 48
49 - 54
55 - 60

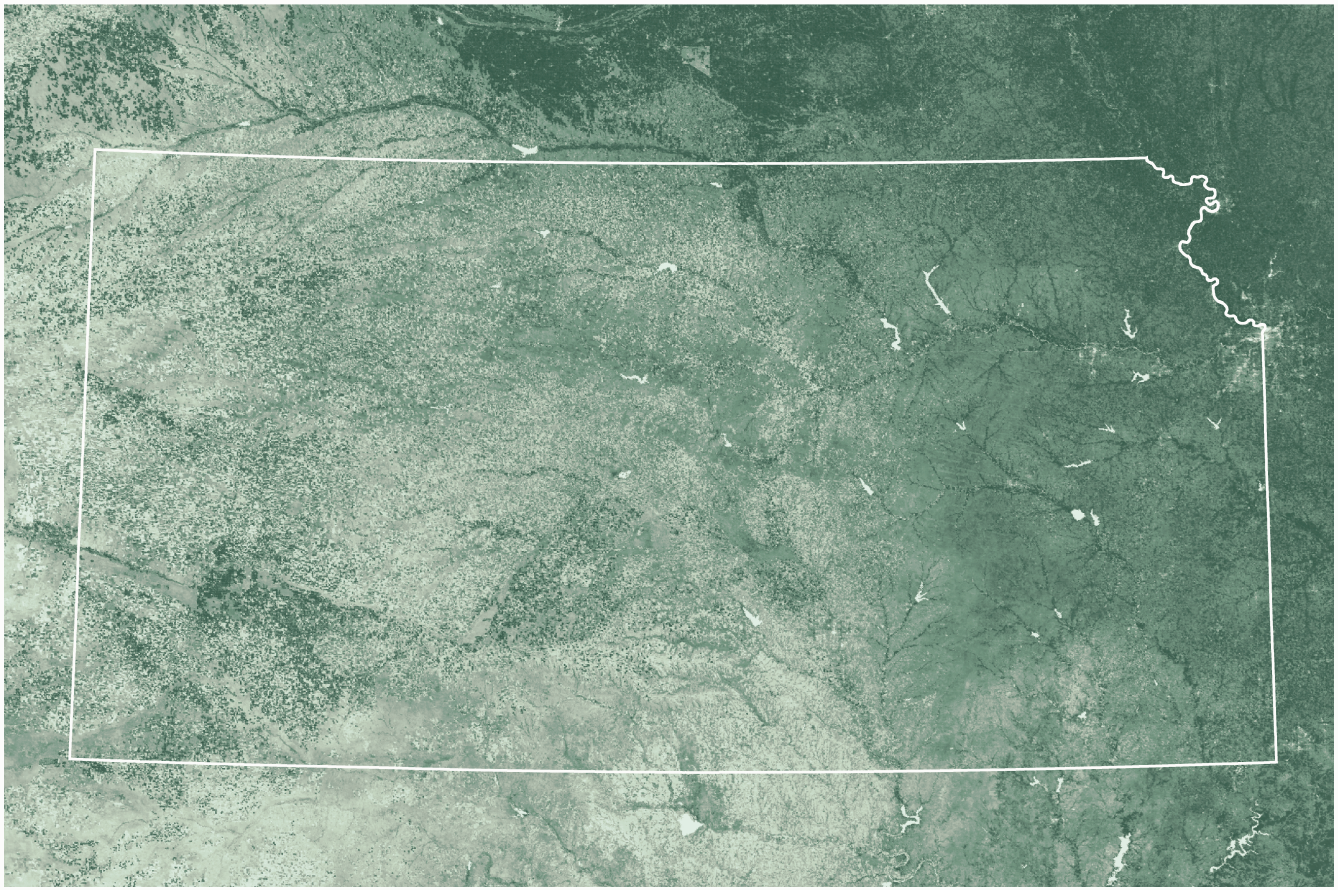
PRISM

Slope

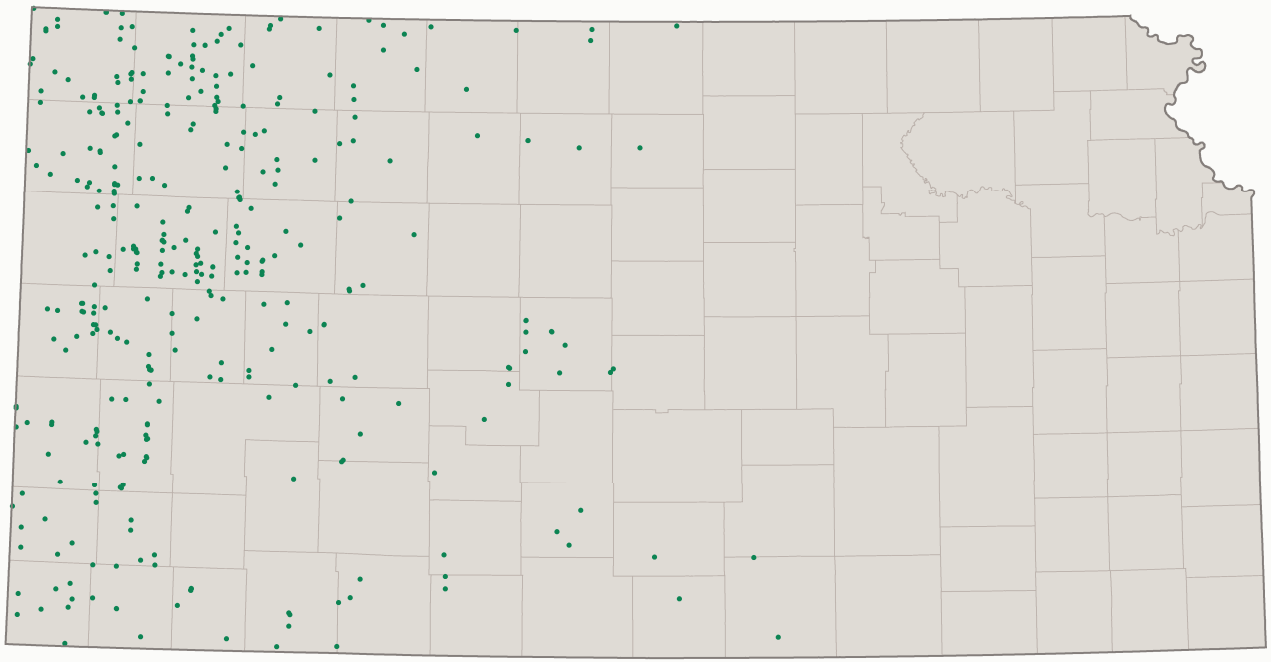
Slope (%)

0 .1 - 1 1.1 - 2 2.1 - 3 3.1 - 4 4.1 - 5 5.1 - 6 6.1 - 8 8.1 - 11 11.1 - 100

Landcover (Vegetation Index)

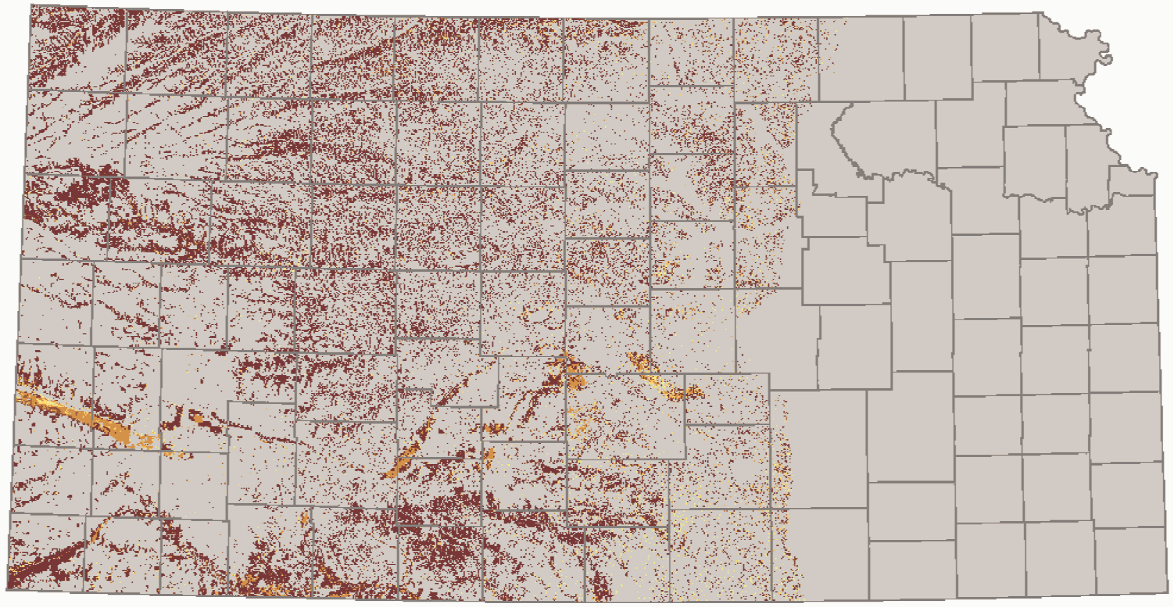


Known Prairie Dog Habitats

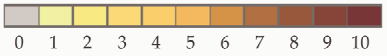


Results

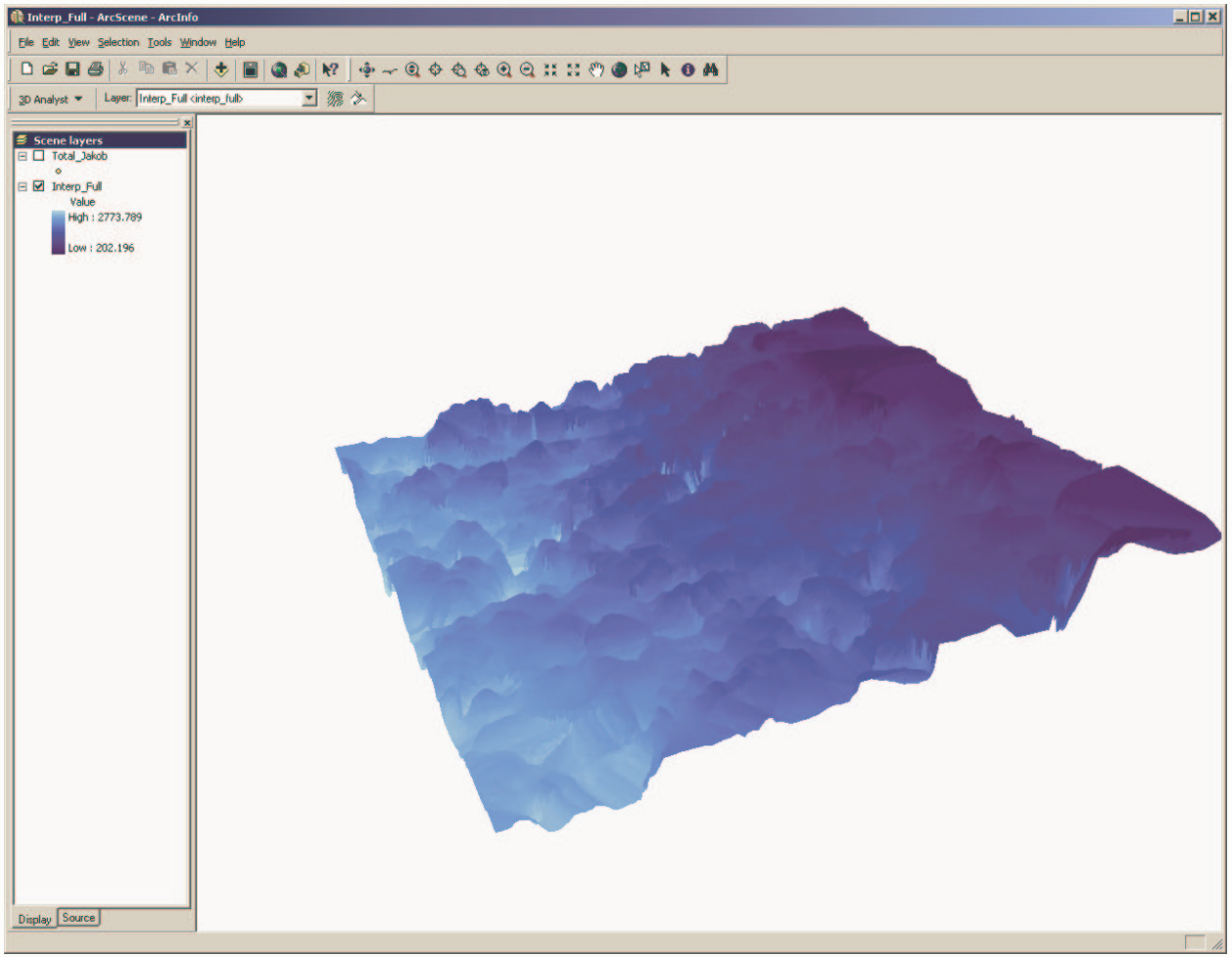
Habitat Suitability for Black-Tailed Prairie Dogs



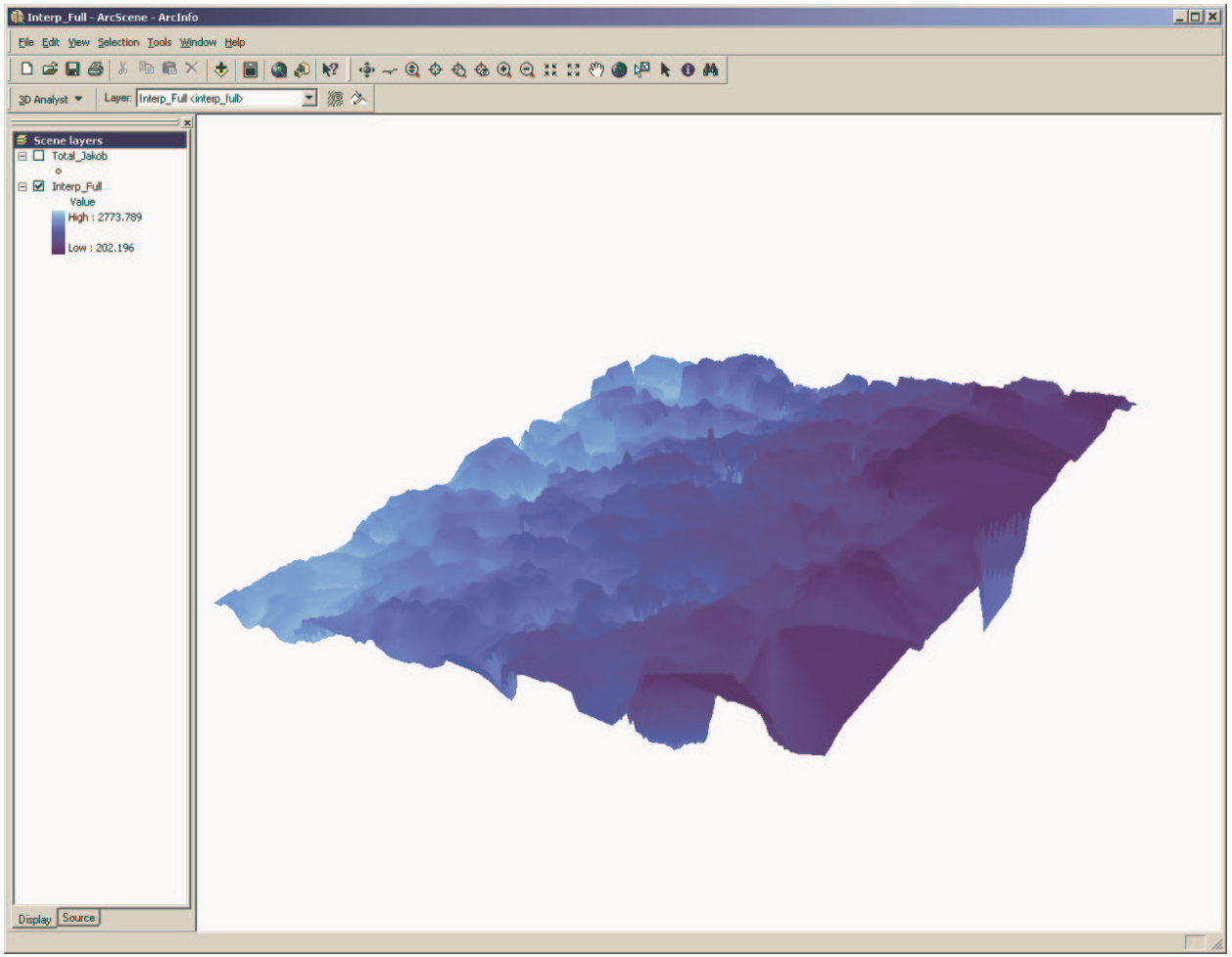
Number of Models Predicting "Presence"



3-D Visualization of Ice Sheet Depth



3-D Visualization of Ice Sheet Depth



How Does GIS Work?

Basic Model of the GIS Process

How Does GIS Work?

- Common Features of a GIS
  - Ability to support a wide range of data *input* options
  - Ability to perform many types of *analysis*
  - Ability to permit a wide-range of *output* options (maps, charts, tables, etc.)

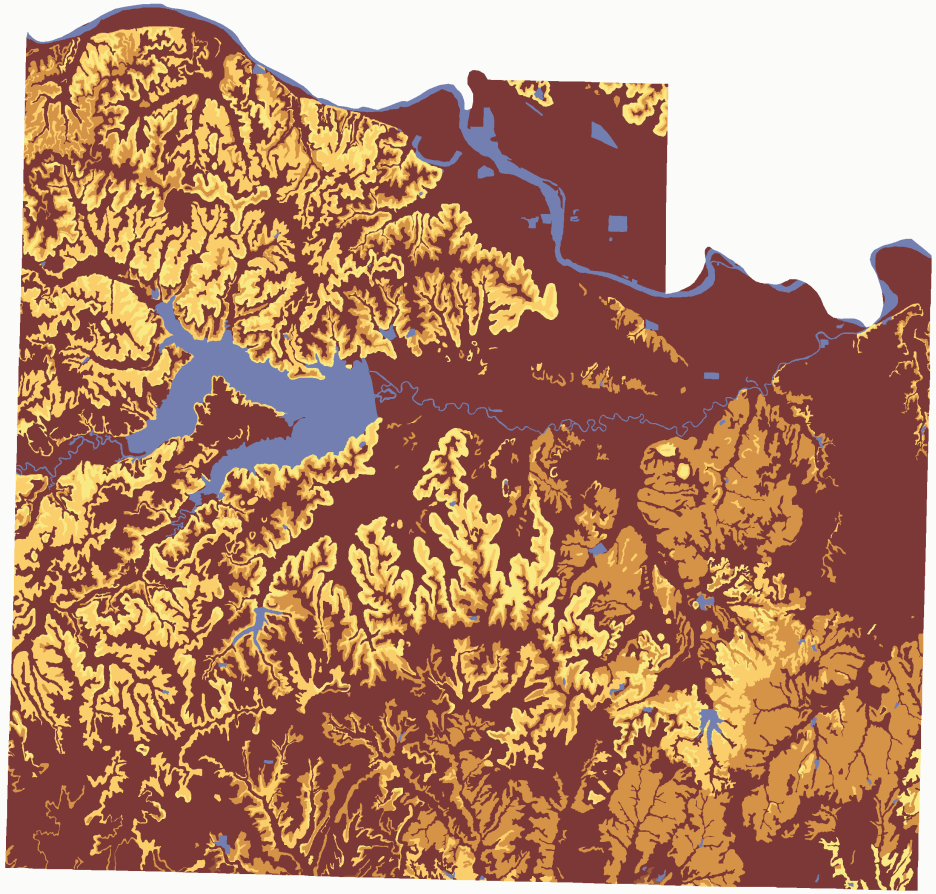
Data Input

- Typical GIS Project will use Several Map Layers
- Sources of Data
  - Digital Data
  - Paper Maps (Scanning and Digitizing)
  - Field Data (Global Positioning System)

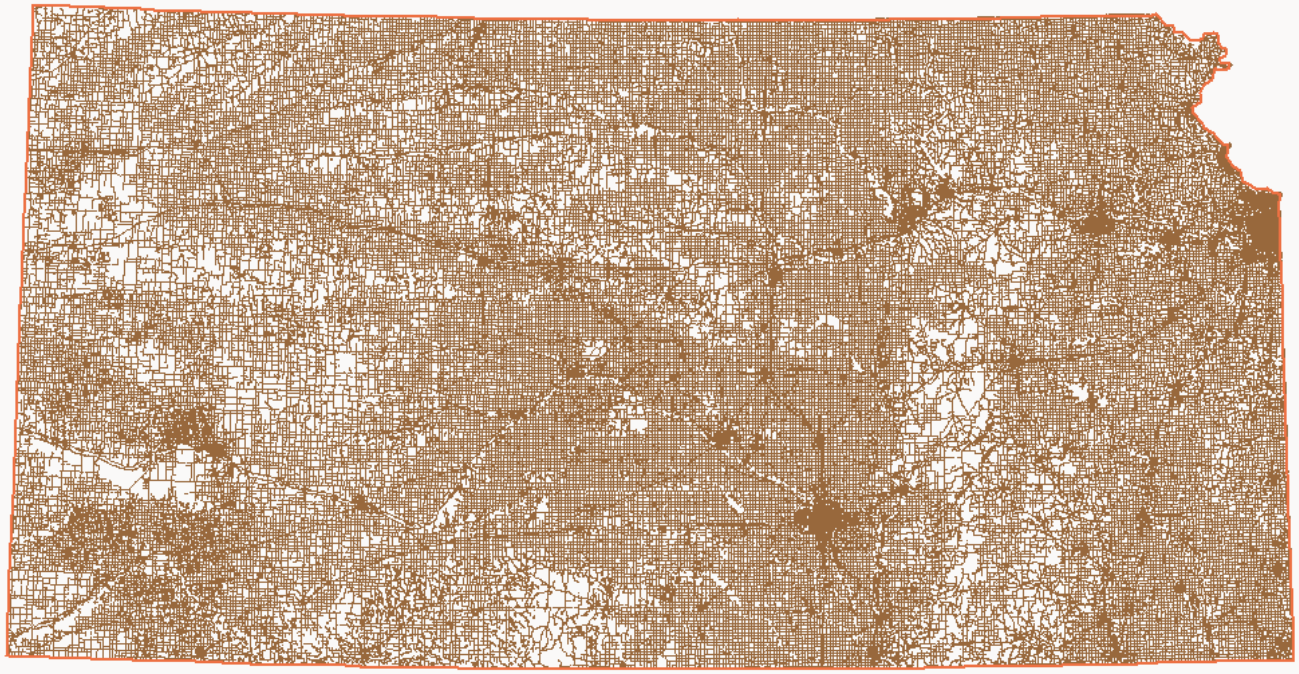
Digital Data

- Digital Map Layers
- Aerial Photography (Orthophotos)
- Satellite Imagery
- Etc.

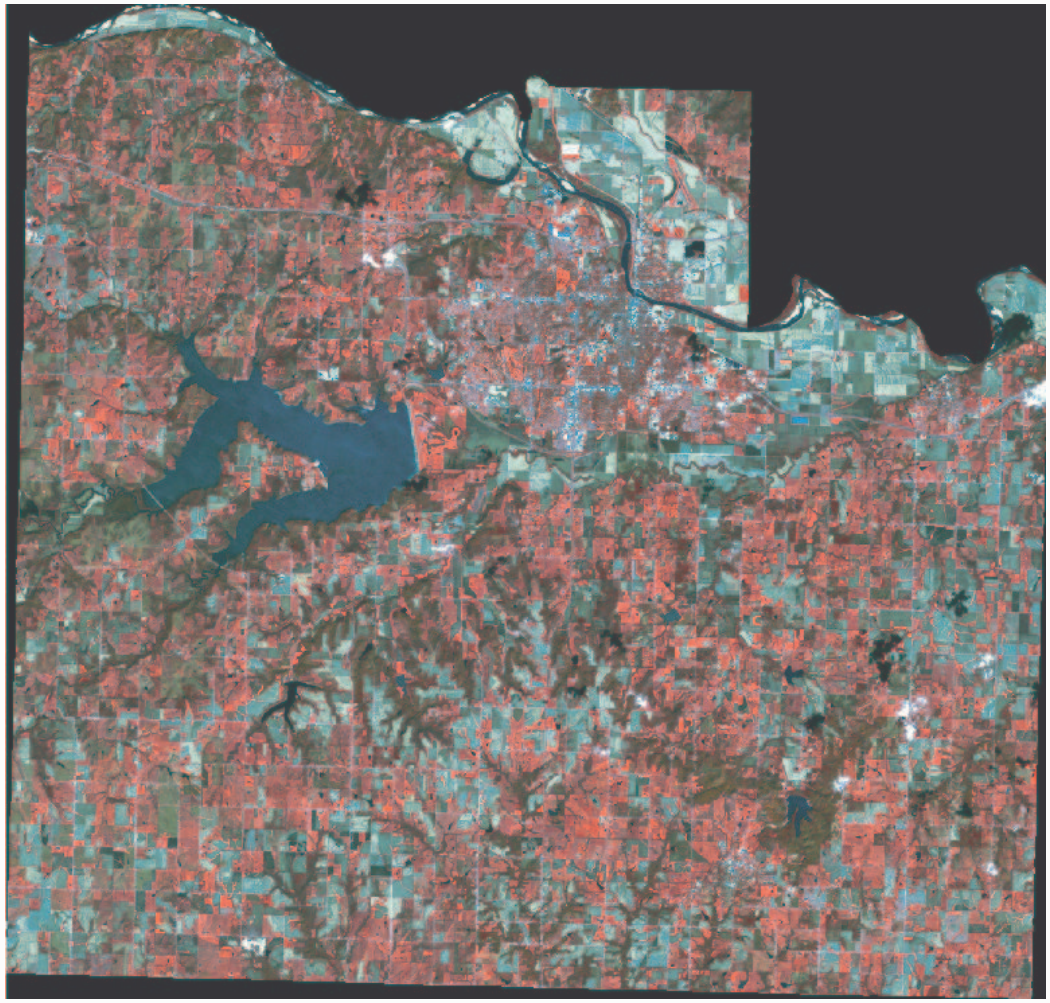
Soils Layer (Douglas County, KS)



Roads Layer (Kansas)



Infrared Satellite Image (Douglas County, KS)

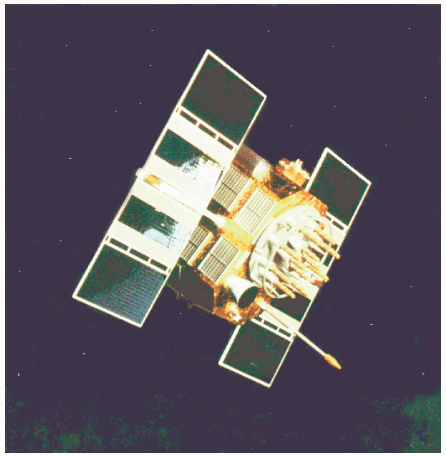


Orthophoto (KU Campus)

GPS and Field Data

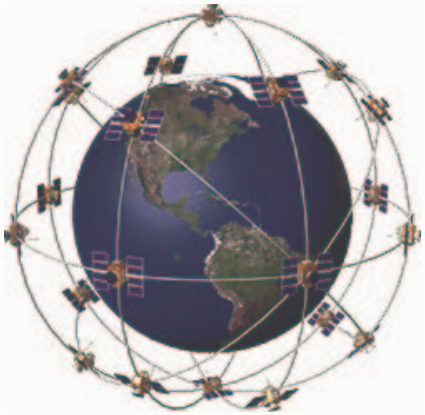
- Global Positioning System (GPS) is system of 24 satellites that send signals
- A GPS receiver receives signals from a satellite and calculates coordinates (latitude and longitude) for the location
- GIS can be used to map GPS coordinates

GPS and Field Data



GPS Satellite

Collecting Coordinates with GPS



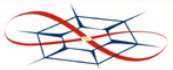
GPS Satellite Orbits

GIS Analysis

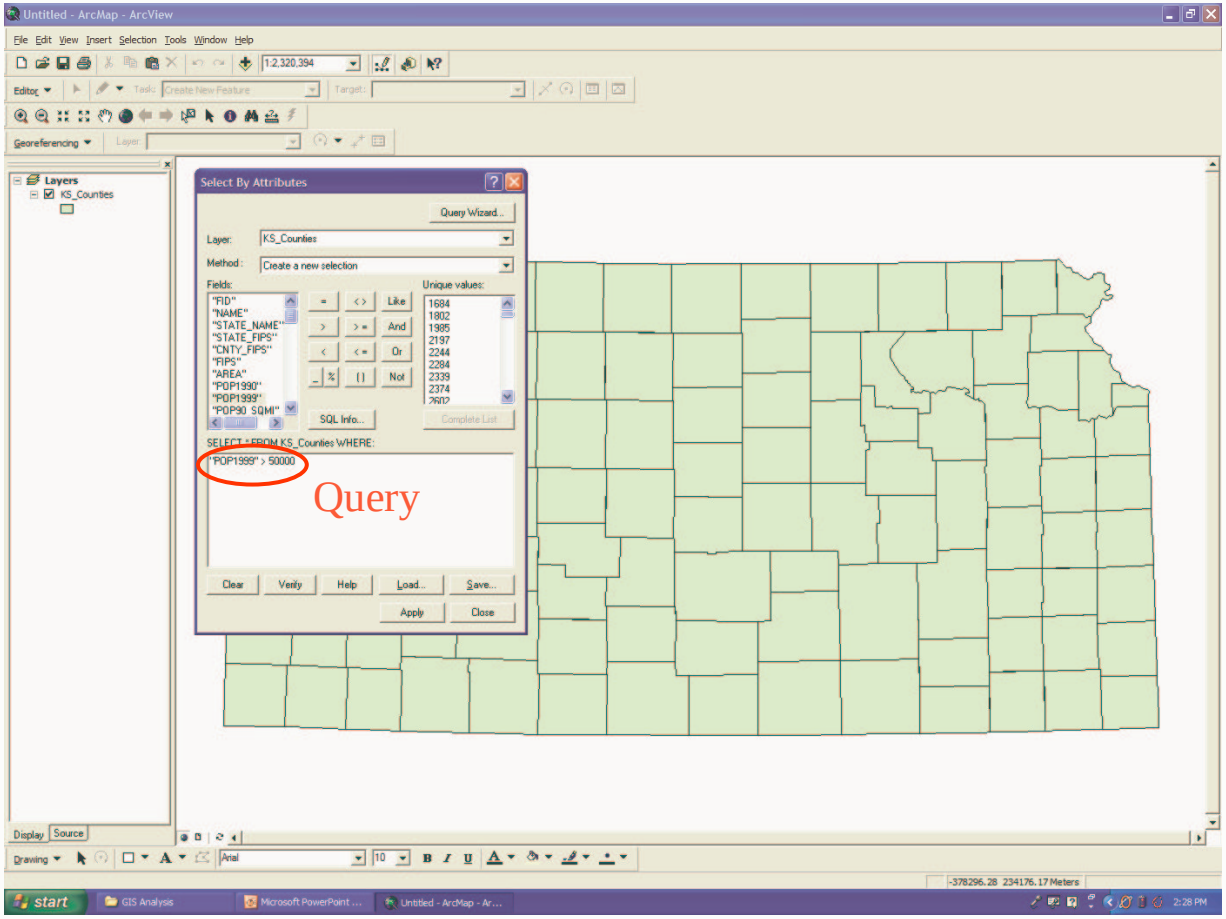
- Analysis is the heart of GIS
- A few common types of analysis…
  - Querying
  - Buffer Analysis
  - Overlay Analysis

Querying

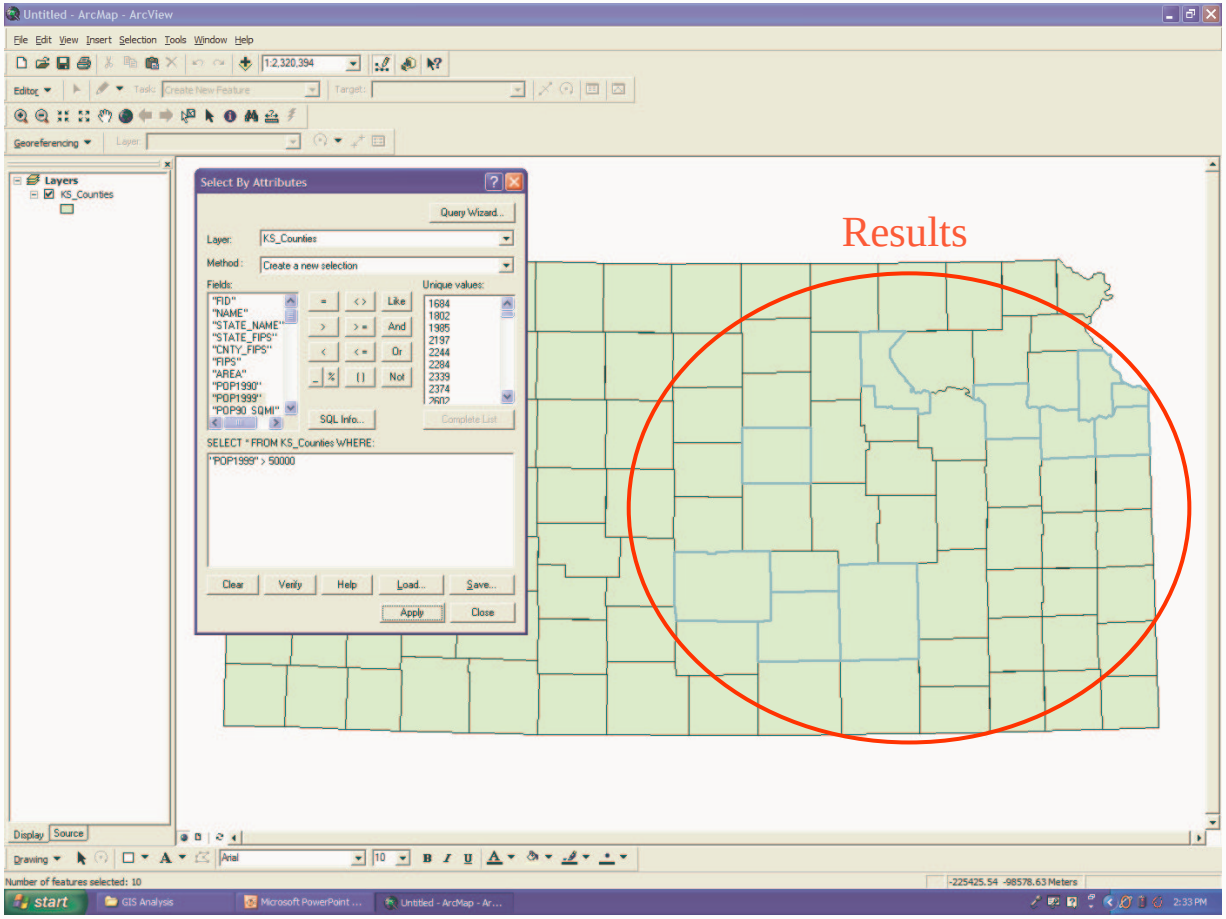
- Querying
  - Similar to asking a question
  - Where are the counties in Kansas with a population of 50,000 or greater?
  - “Population” > 50000

Example of Querying



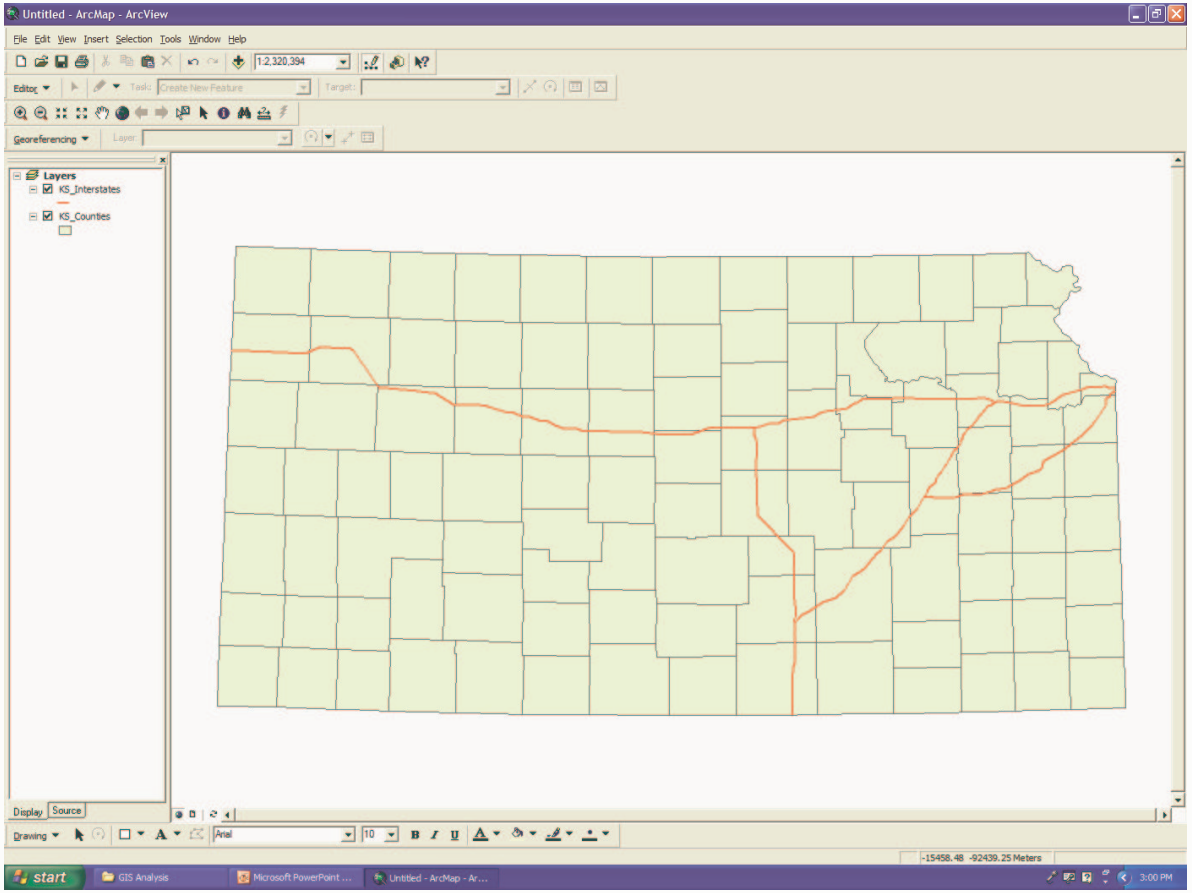
Example of Querying



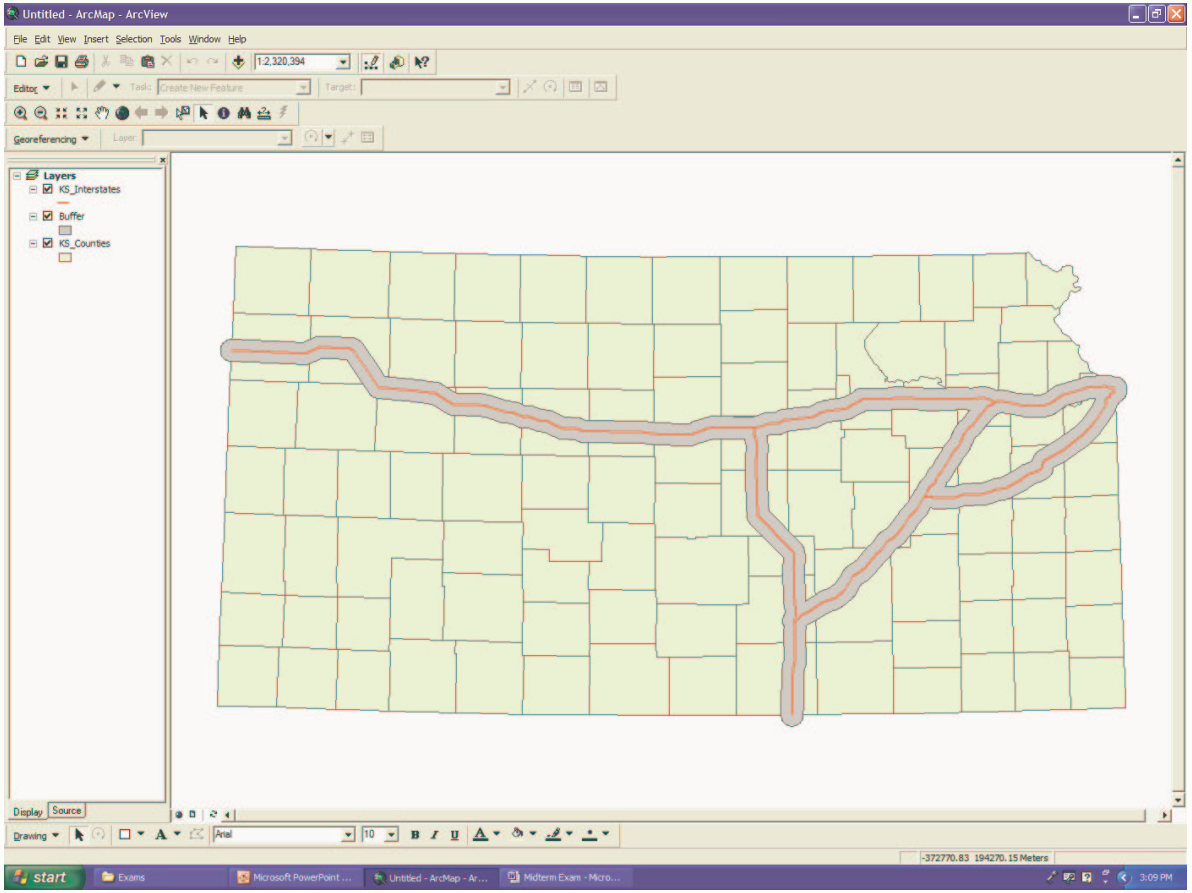
Buffer Analysis

- Buffering
  - Distance operation
  - Where are all areas within 5 miles of the Interstate highways in Kansas?
  - "Buffer" of a specified distance is drawn around features

Example of Buffering (5 miles)



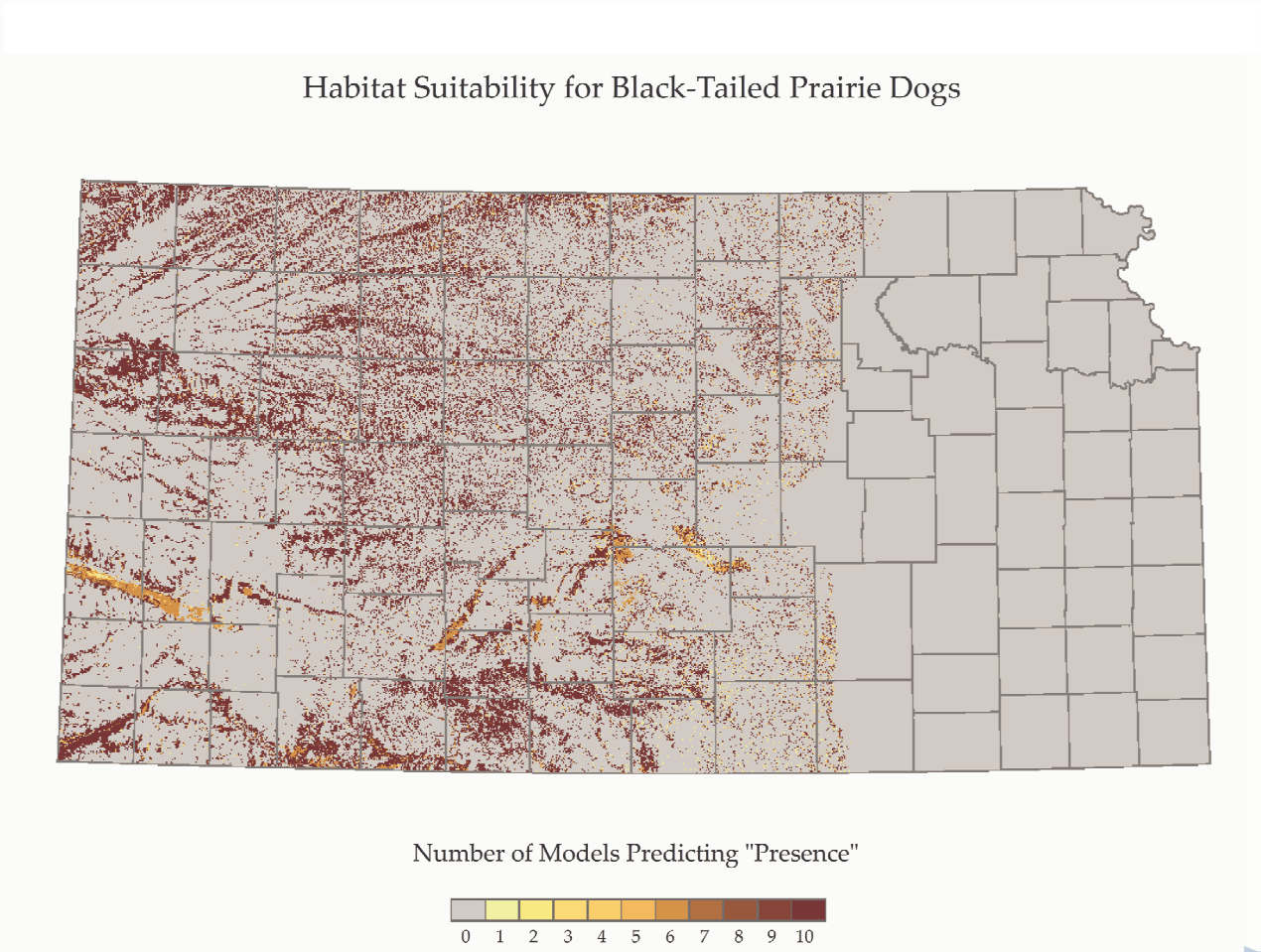
Example of Buffering (5 miles)



Output/Results

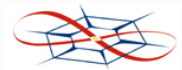
- Output may include:
  - Maps
  - Charts
  - Tables
  - Graphs
  - Statistics
  - Etc.
- GIS software has several options for symbolizing and designing maps.

Output/Results



GIS and PRISM

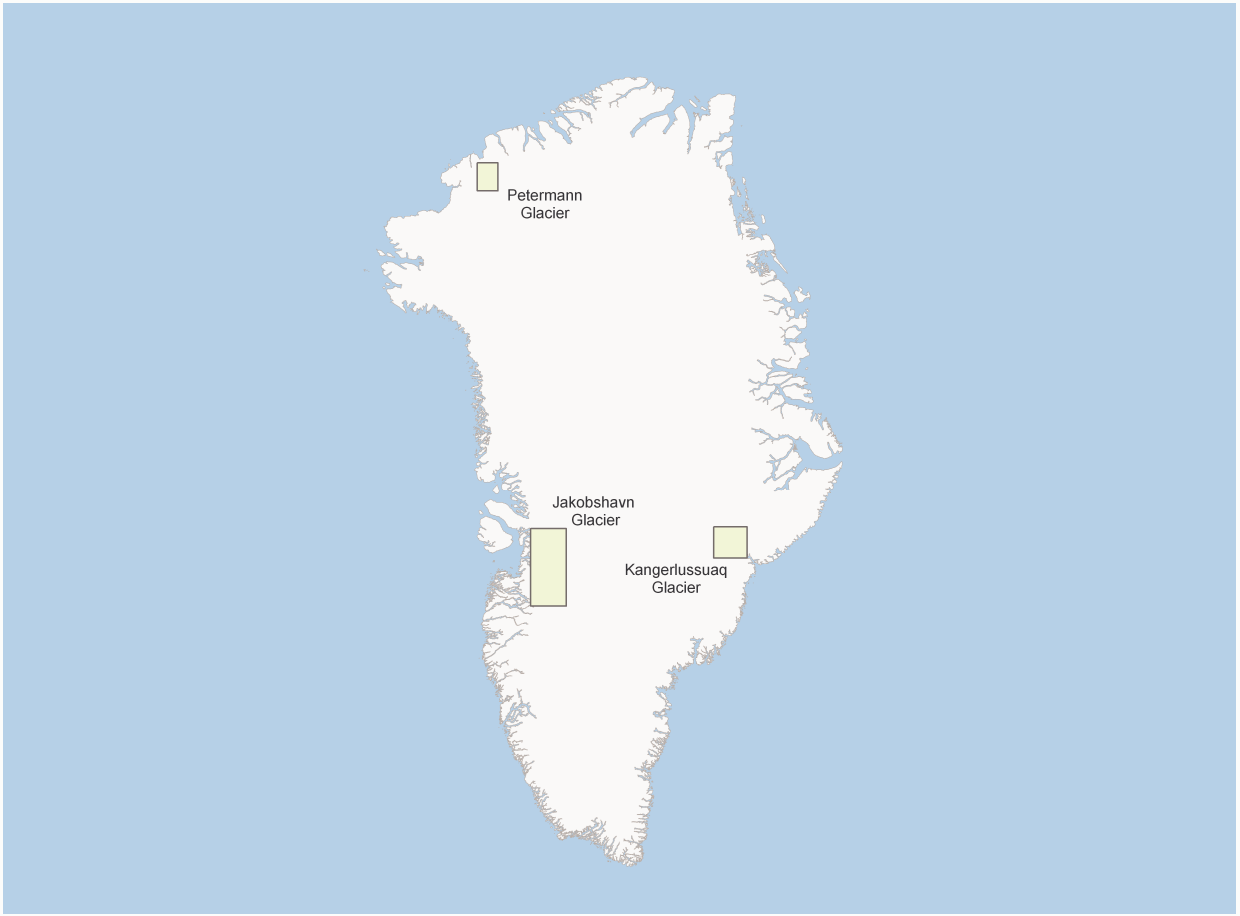
- PRISM Project Overview
  - Polar Research for Ice Sheet Measurement
  - Global warming and melting of the ice sheets
  - Geographic questions
    - Where is the thickness of the ice sheet greatest?
    - Where is the thickness of the ice sheet smallest?
    - How does the thickness of the ice sheet vary over space?

GIS and PRISM

- Acknowledgement
  - Harish Ramamoorthy, ITTC
  - "Radar Depth Sounder Processing and Digital Thickness Map of Outlet Glaciers."

Study Areas


Petermann
Glacier
Jakobshavn
Glacier
Kangerlussuaq
Glacier

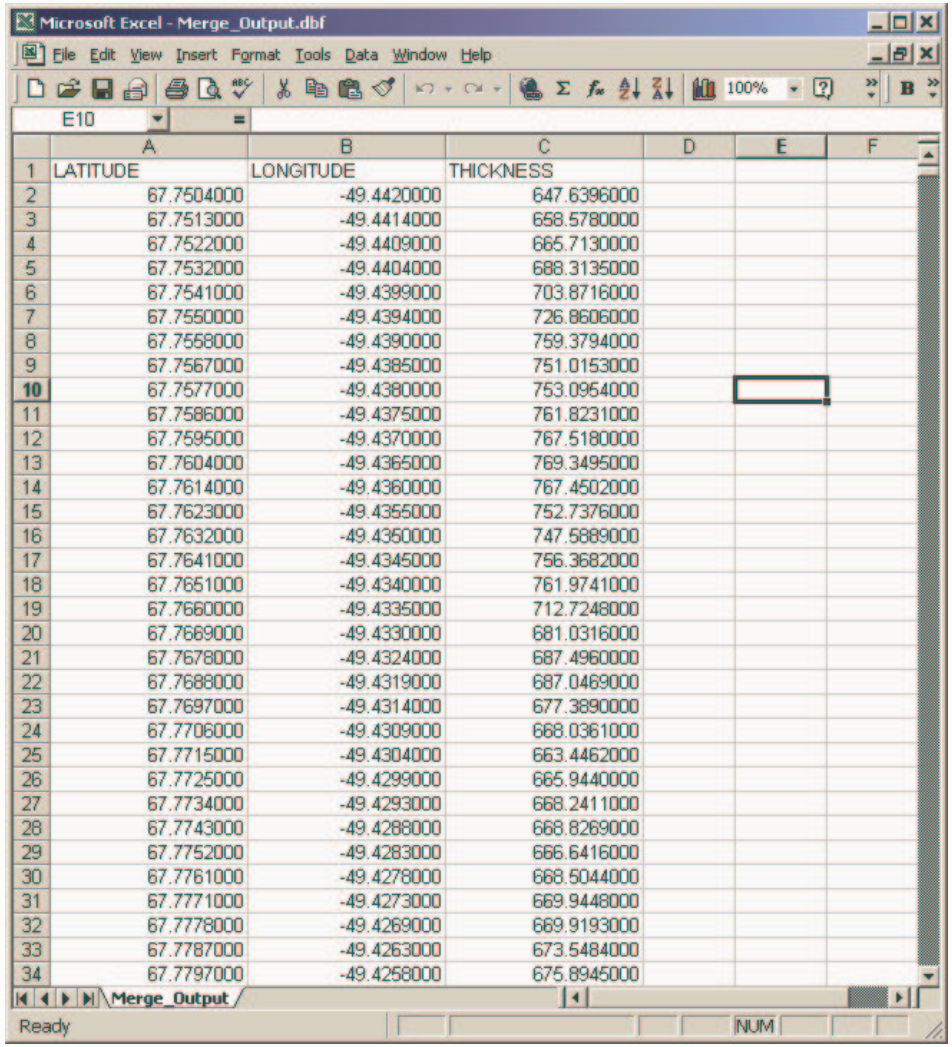
Methods

- Data Collection
  - Ground penetrating radar on aircraft gathered ice sheet thickness data around outlet glaciers
  - Data for 1997, 1998, 1999, 2001, 2002, 2003
  - In 2003, 9000+ sample points collected for Jakobshavn outlet glacier

Methods

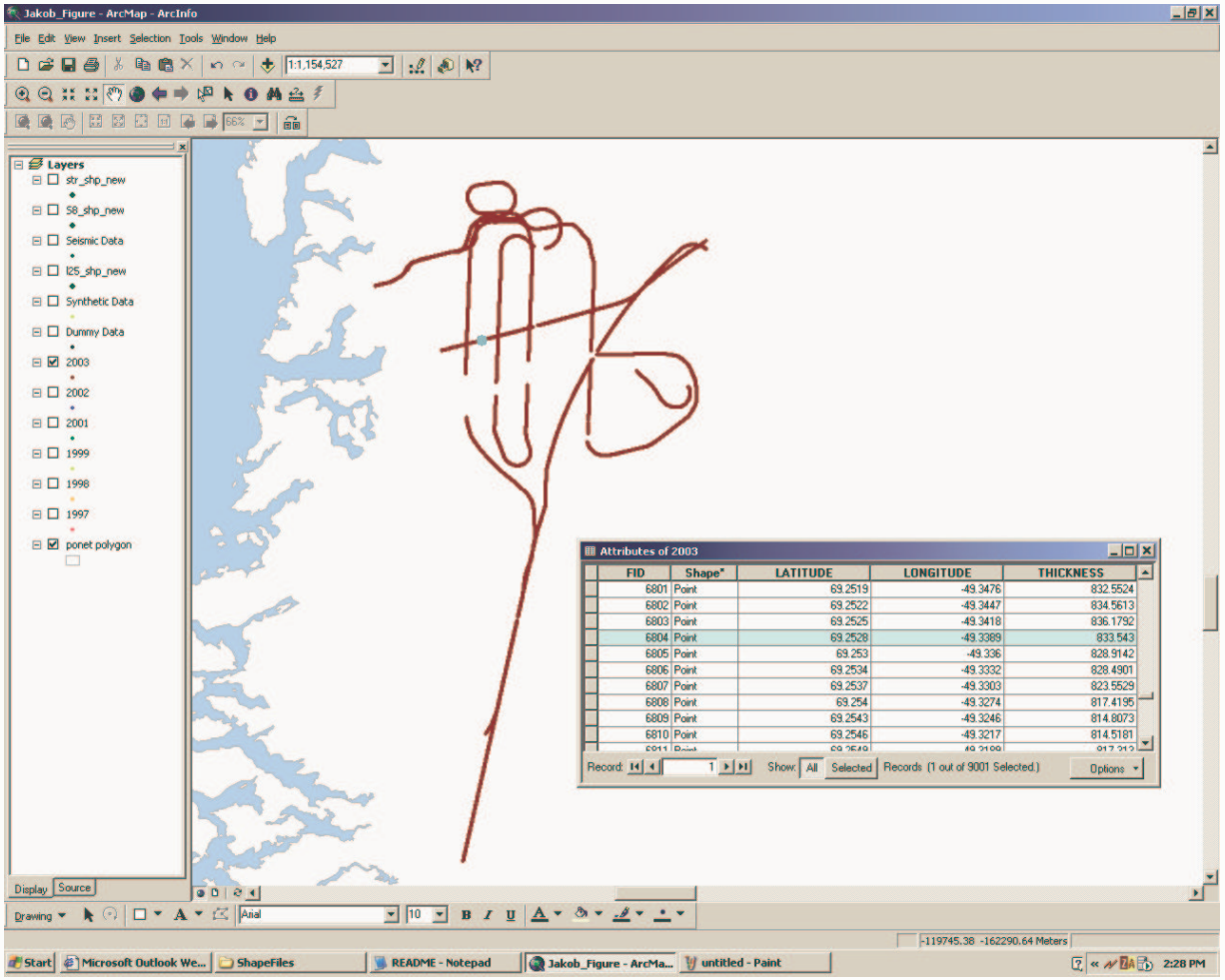
- GIS
  - Sample points mapped in GIS
  - Interpolated surface of ice sheet thickness
  - 3-D visualization of ice sheet thickness

Thickness Data



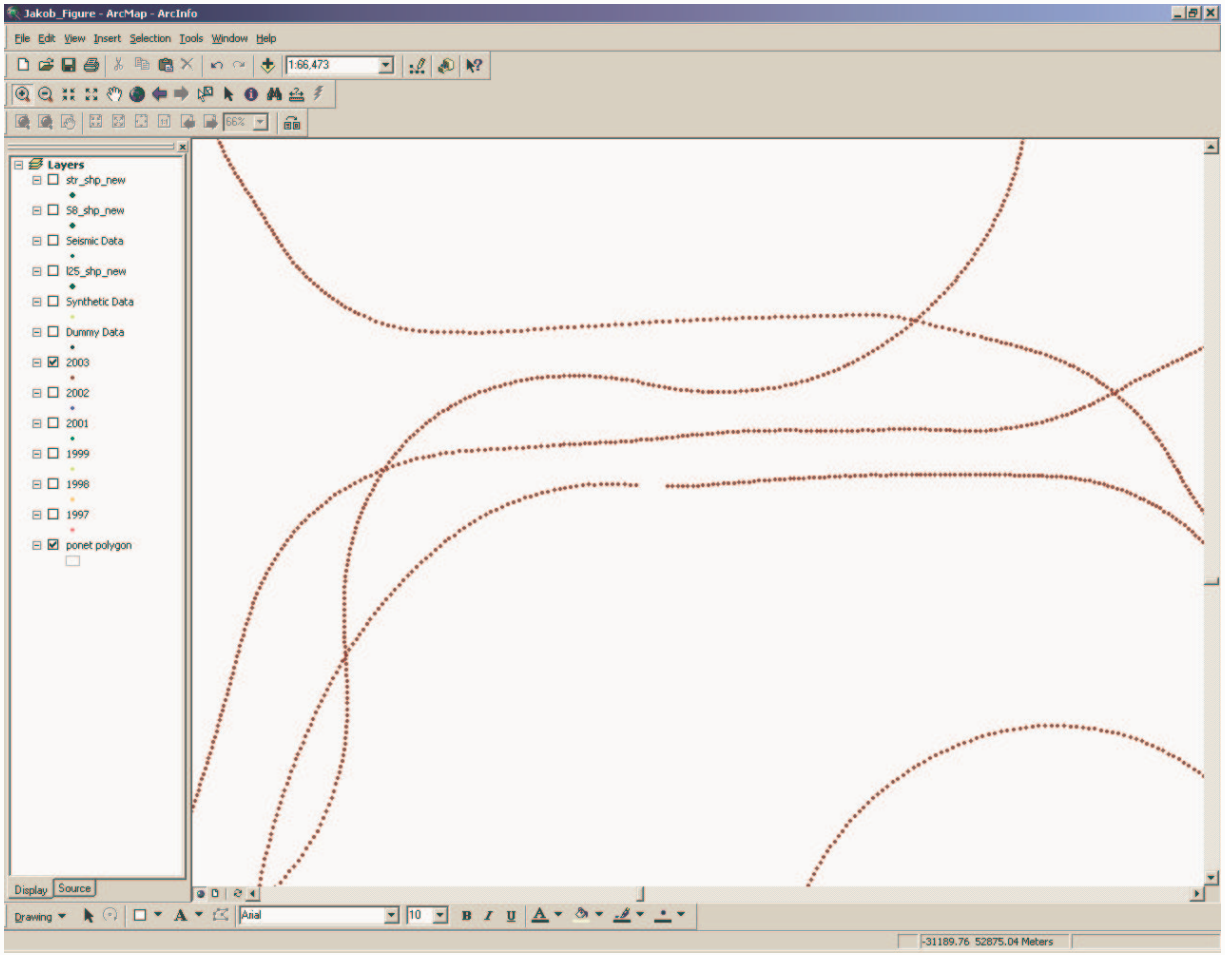
	A	B	C	D	E	F
1	LATITUDE	LONGITUDE	THICKNESS			
2	67.7504000	-49.4420000	647.6396000			
3	67.7513000	-49.4414000	658.5780000			
4	67.7522000	-49.4409000	665.7130000			
5	67.7532000	-49.4404000	688.3135000			
6	67.7541000	-49.4399000	703.8716000			
7	67.7550000	-49.4394000	726.8606000			
8	67.7558000	-49.4390000	759.3794000			
9	67.7567000	-49.4385000	751.0153000			
10	67.7577000	-49.4380000	753.0954000			
11	67.7586000	-49.4375000	761.8231000			
12	67.7595000	-49.4370000	767.5180000			
13	67.7604000	-49.4365000	769.3495000			
14	67.7614000	-49.4360000	767.4502000			
15	67.7623000	-49.4355000	752.7376000			
16	67.7632000	-49.4350000	747.5889000			
17	67.7641000	-49.4345000	756.3682000			
18	67.7651000	-49.4340000	761.9741000			
19	67.7660000	-49.4335000	712.7248000			
20	67.7669000	-49.4330000	681.0316000			
21	67.7678000	-49.4324000	687.4960000			
22	67.7688000	-49.4319000	687.0469000			
23	67.7697000	-49.4314000	677.3890000			
24	67.7706000	-49.4309000	668.0361000			
25	67.7715000	-49.4304000	663.4462000			
26	67.7725000	-49.4299000	665.9440000			
27	67.7734000	-49.4293000	668.2411000			
28	67.7743000	-49.4288000	668.8269000			
29	67.7752000	-49.4283000	666.6416000			
30	67.7761000	-49.4278000	668.5044000			
31	67.7771000	-49.4273000	669.9448000			
32	67.7778000	-49.4269000	669.9193000			
33	67.7787000	-49.4263000	673.5484000			
34	67.7797000	-49.4258000	675.8945000			

Thickness Data Plotted in GIS

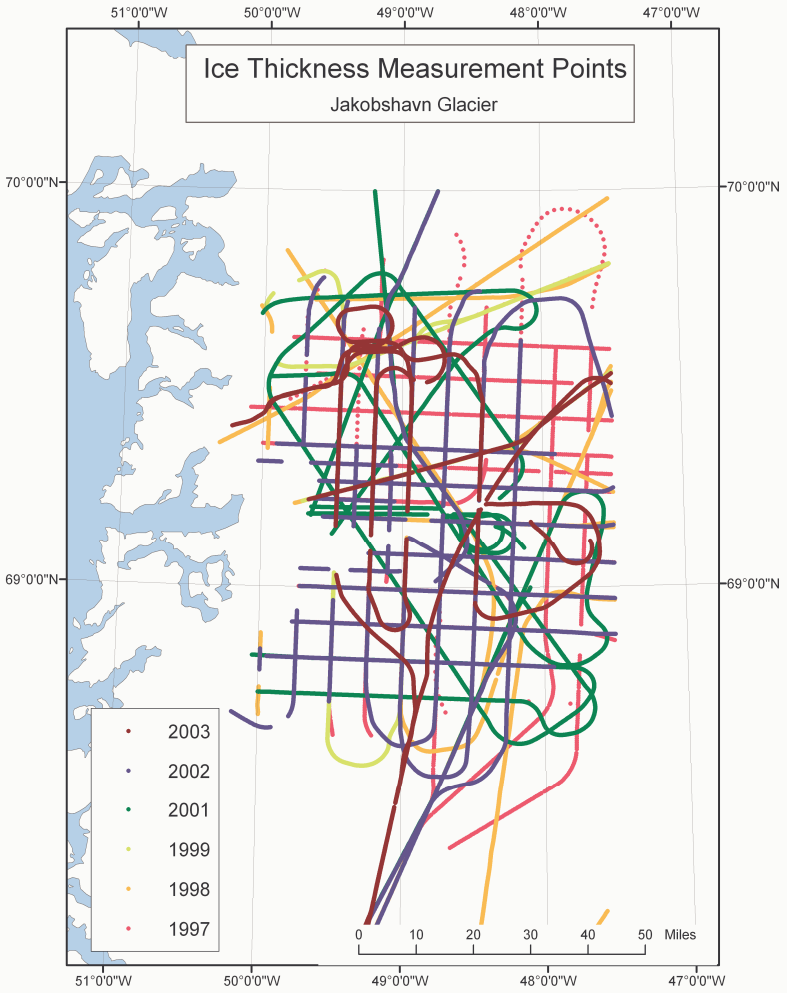


PRISM

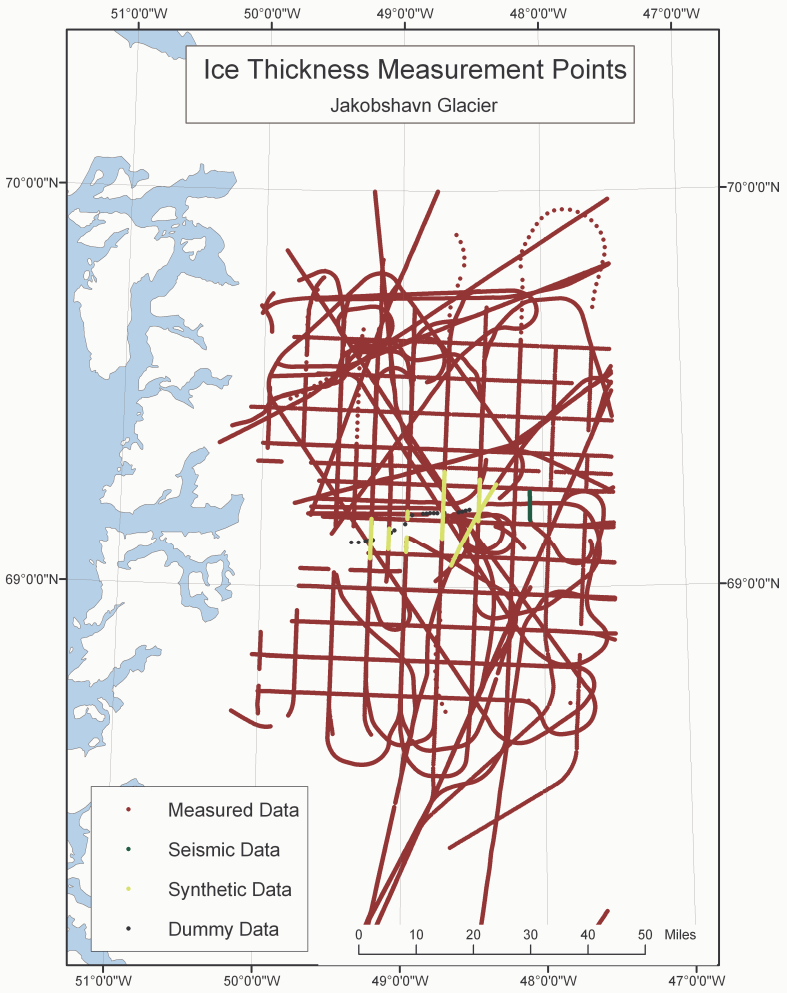
Thickness Data Points



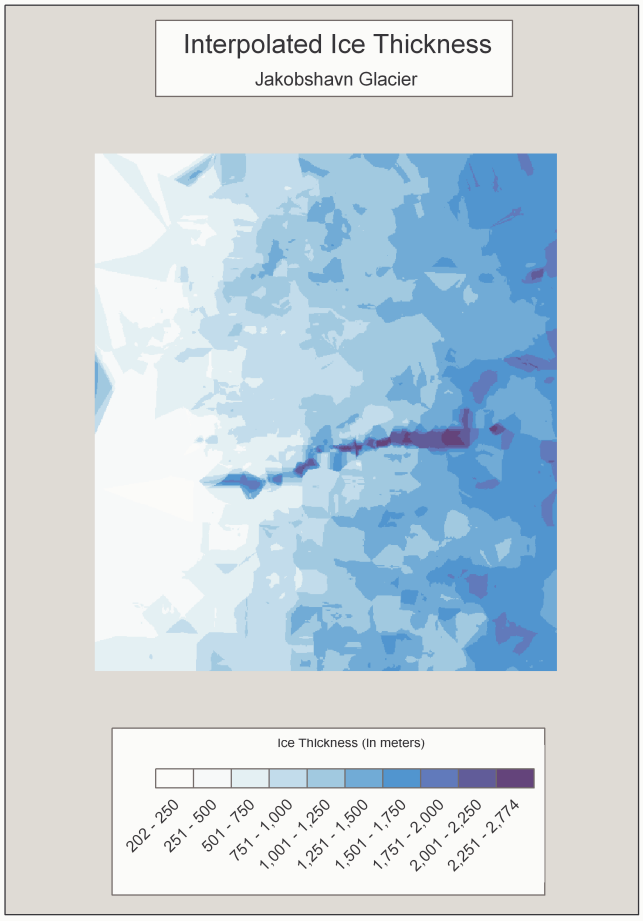
Thickness Measurement Points for all Years



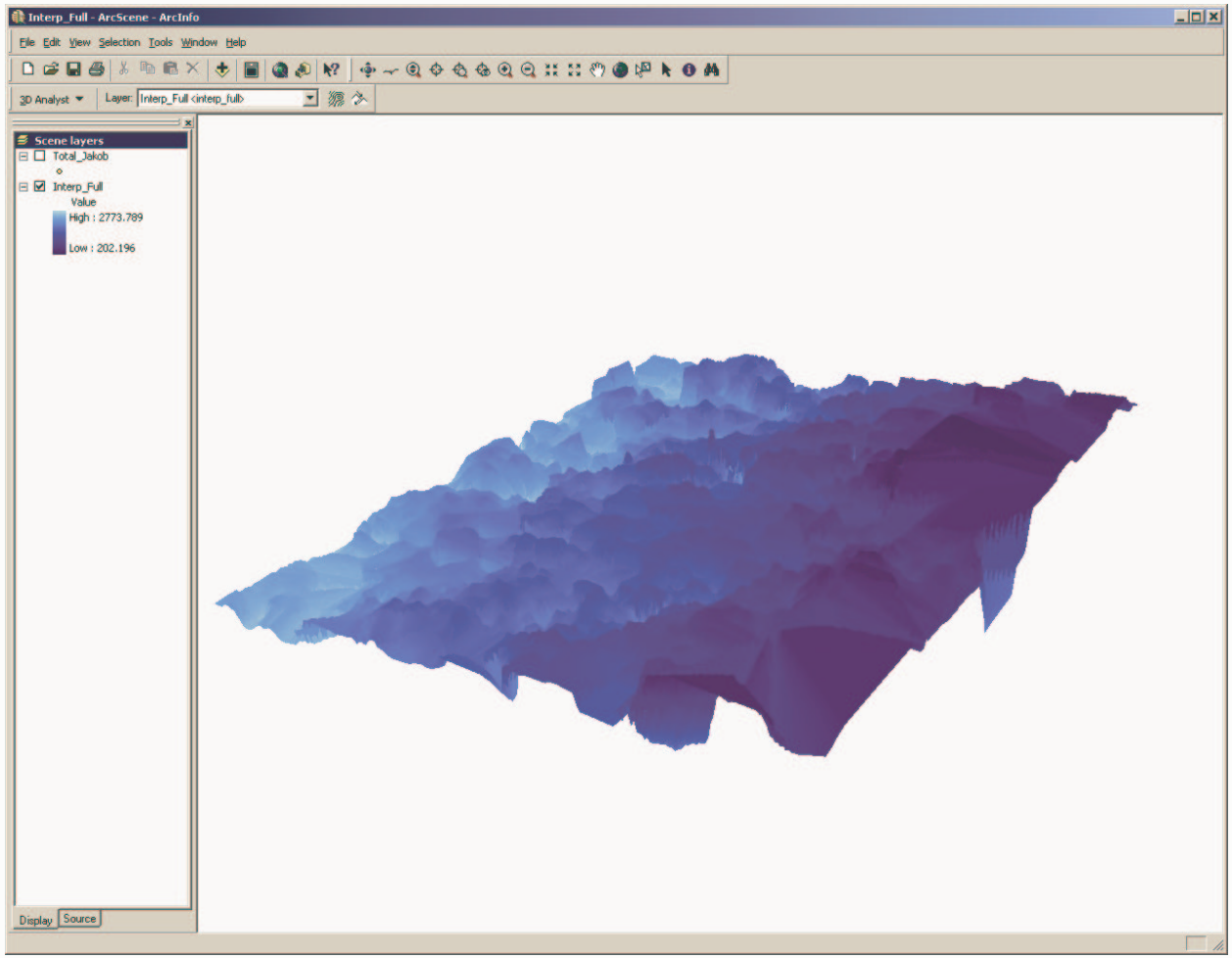
Additional Data Added



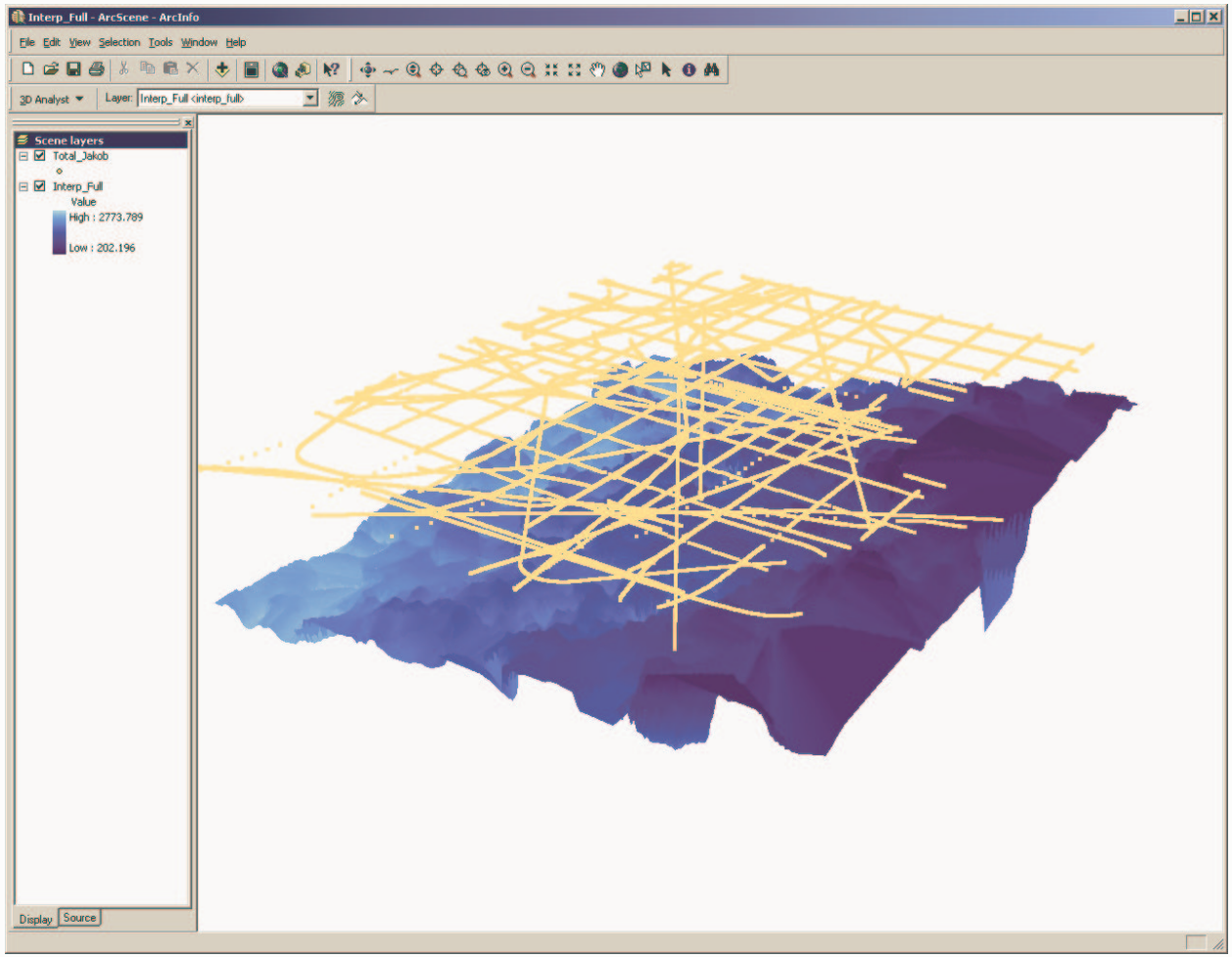
Interpolated Thickness Map



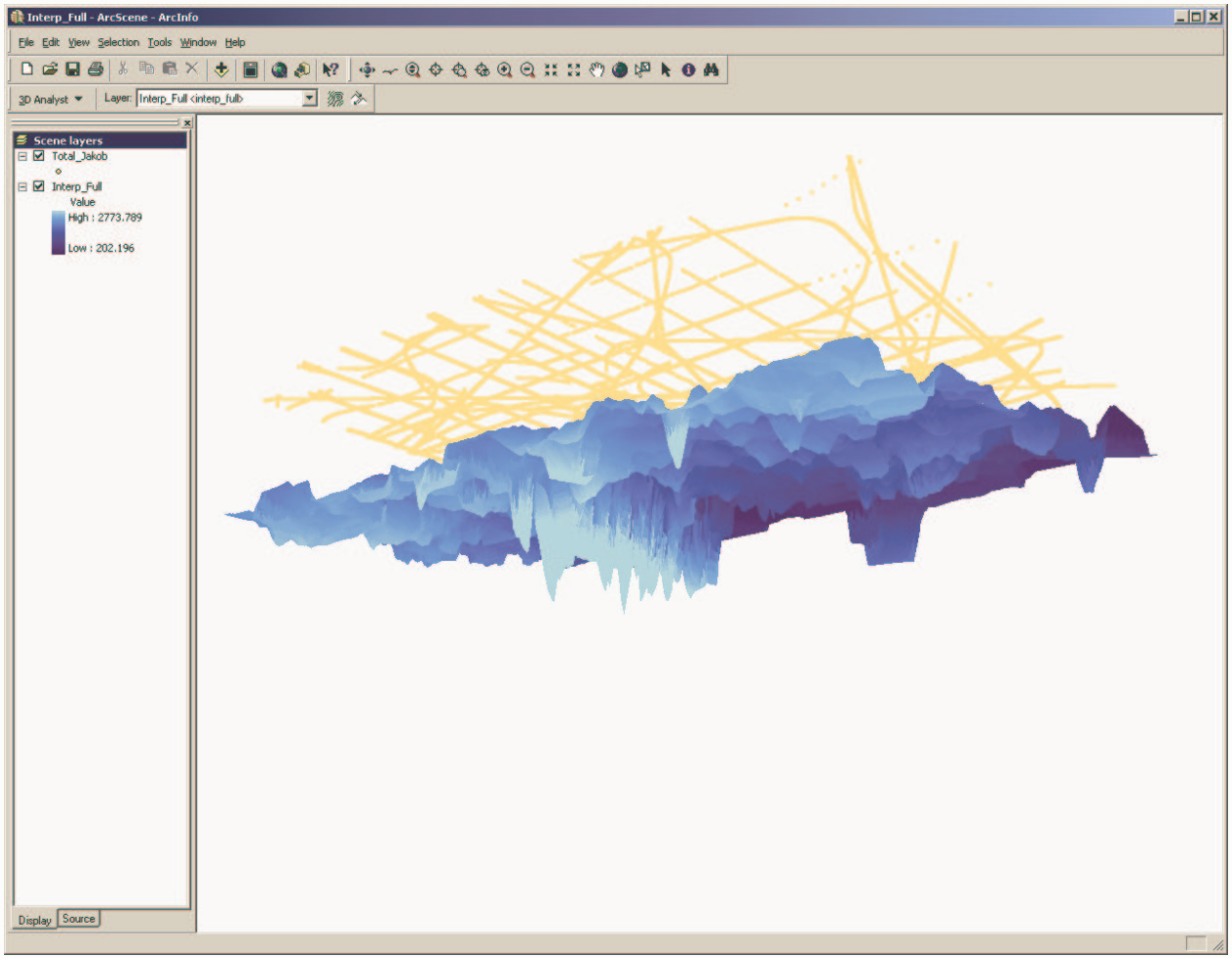
3-D Visualization of Ice Thickness



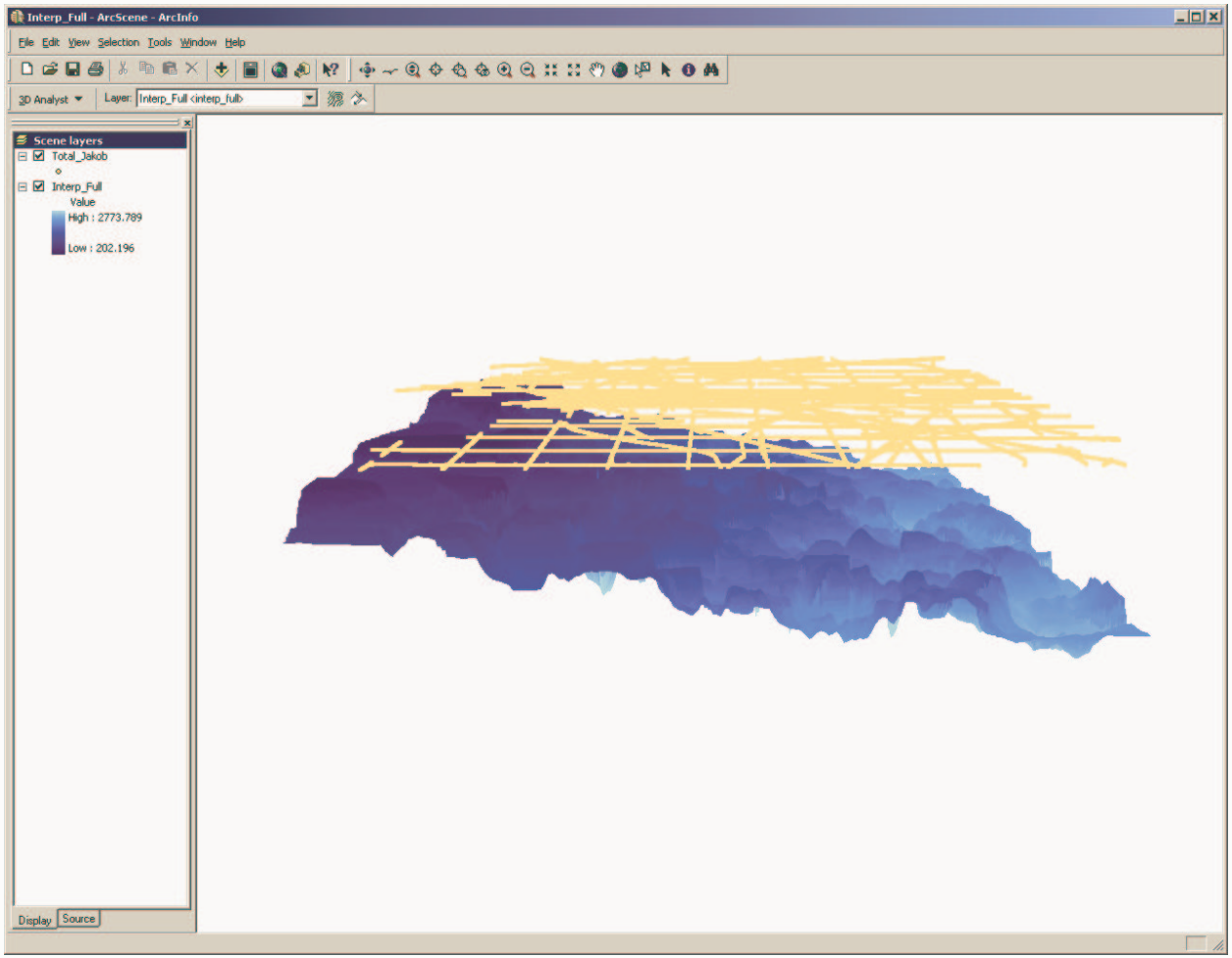
3-D Visualization of Ice Thickness



3-D Visualization of Ice Thickness



3-D Visualization of Ice Thickness



Summary

- Several scientific questions are geographic or spatial in nature
- GIS can help answer these questions
- GIS has applications in many disciplines in science, including PRISM and ice thickness research