



# INTRODUCTION TO GIS

Dartmouth College | Research Computing



# OVERVIEW

- Workshops
- GIS at Dartmouth
- What is GIS?
- Types of Data
- Referencing data to the earth: Datums, Map Projections, and Coordinate Systems
- Working with GIS
- Hands-on practice
- Data Sources, Data Formats & Metadata
- Software – Desktop & Web
- Data Management

# WORKSHOPS

- Training & Workshops
- Consulting
- High-Performance Computing
- <http://rc.dartmouth.edu/>

The screenshot shows the website for Research Computing at Dartmouth. The header includes the RC logo and navigation links for 'Request an Account', 'Contact Us', and 'Request Help'. A secondary navigation bar lists 'High Performance Computing', 'Services', 'Help', 'Training' (highlighted), 'Partnership', 'News', and 'About Us'. The main content area is titled 'Training' and contains a paragraph about live training sessions, a search bar, and a 'Recent Posts' section with links to 'Upcoming Workshops and Training', 'Geospatial Community Luncheon', 'Programming, Arduinos N' Pizza - November '17', and 'UPCOMING Programming N'Pizza'. Below the text is a calendar for December 2017 with a table of dates. Underneath the calendar is a list of 'Upcoming Events' including workshops on Geographic Information Systems, R programming, and Matlab, along with a database design tutorial.

rc.dartmouth.edu/index.php/training/

**RC** INFORMATION, TECHNOLOGY & CONSULTING  
Research Computing AT DARTMOUTH

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High Performance Computing Services Help **Training** Partnership News About Us

## Training

Research Computing helps you learn how to use research software and systems through our live training sessions and online classes.

Browse the following calendar to learn more about the classes/trainings/workshops already scheduled. Click on the title to obtain more information and to register.

December 2017						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

**Upcoming Events:**

- Workshop: Introduction to Geographic Information Systems  
1/17/2018 2:00pm
- Programming with R, part 1  
1/23/2018 2:00pm
- Programming with R, part 2  
1/25/2018 2:00pm
- Introduction to Matlab  
2/8/2018 10:00am
- Hands-on Tutorial: Introduction to Database Design and Implementation  
2/6/2018 2:00pm

Show All

Search

### Recent Posts

- Upcoming Workshops and Training
- Geospatial Community Luncheon
- Programming, Arduinos N' Pizza – November '17
- UPCOMING Programming N'Pizza
- Programming N' Pizza

### Keep in Touch

E-mail us

# GIS AT DARTMOUTH

- Geography Department, Earth Sciences Department
  - Geography <http://geography.dartmouth.edu/> Earth Sci: <http://earthsciences.dartmouth.edu/>
    - Geog 50 Geographic Information Systems (Fall 2018)
    - Geog 57 Urban Applications of GIS (Fall 2018)
    - Geog 51 / Ears 65: Remote Sensing
    - Geog 54 Geovisualization (Winter 2019)
    - Geog 59/Ears 77 Environmental Applications of GIS
- Resources in the Library Reference Research Guides and Evans Map Room
  - <http://researchguides.dartmouth.edu/gis>
  - <https://researchguides.dartmouth.edu/webmapping>
- Research Computing: Promoting the advancement of research through the use of high-performance computing (HPC), GIS and Life Sciences applications consulting, services and workshops.
  - <http://rc.dartmouth.edu/>
    - Accounts for researchers (50 GB for graduate students, 1TB for faculty)
    - List of workshops & events
  - Contact Info: [Research.Computing@dartmouth.edu](mailto:Research.Computing@dartmouth.edu)

# GIS AT DARTMOUTH

The screenshot shows the Dartmouth College Library Research Guides website. The header includes the Dartmouth College logo and the text "DARTMOUTH COLLEGE LIBRARY RESEARCH GUIDES". Below this, there are navigation links for "Dartmouth Home", "Library Home", and "Off-Campus Access". The main content area is titled "Geographic Information Systems/Science: A Research Guide: The Basics of GIS". It features a search bar with the text "Search this Guide" and a "Search" button. Below the search bar, there is a paragraph of introductory text: "This is a library resource guide for GIS. There are several departments on campus which use GIS. They include but are not limited to Geography, Earth Sciences, Environmental Studies, Biological Sciences and Economics." A grid of topic tags is displayed, including "The Basics of GIS", "Getting Started with GIS", "Selected Book Titles for GIS", "GIS Software", "Esri Maps for Excel", "Open source software", "GIS Manuals", "Python", "Articles & Journals", "GIS for the Mac", "Case studies in GIS", "Archaeology & GIS", "Census & GIS", "ENVS & GIS", "History & GIS", "Urban Applications", "Spatial Analysis & Modelling", "Public Health", "ArcGIS Online", "Internet Resources for GIS", "GIS Education Blog", "Online mapping", "Digital Mapping", "GIS Data", "Google Earth & Maps", "Visualization", "Managing Citations", and "Scholarly communication". At the bottom, there is a section titled "Keeping up with the journal literature" with a sub-section "Keeping current in GIS literature" and a small image of a smartphone displaying a map.

The screenshot shows the Dartmouth College Geography department website. The browser address bar displays "Secure | https://geography.dartmouth.edu/undergraduate/courses". The page is titled "FALL 2018" and lists several courses with their respective instructors and credit hours:

- [GEOG 1](#): Introduction to Human Geography - [Fox](#) (10)
- [GEOG 3](#): The Natural Environment - [Spera](#) (12)
- [GEOG 4](#): Global Poverty & Care - [Lopez](#) (2A)
- [GEOG 6/INTS 16](#): Introduction to International Development - [Freid](#)
- [GEOG 22](#): Urban Geography - [Domosh](#) (11)
- [GEOG 24](#): American Landscapes and Cultures - [Domosh](#) (2)
- [GEOG 50](#): Geographical Information Systems - [Shi](#) (12)
- [GEOG 57](#): Urban Applications of GIS - [Shi](#) (11)
- [GEOG 67/ENVS 67](#): Political Ecology - [Sneddon](#) (10A)
- [GEOG 90](#): Research in Geography - [Fox](#)(12)
- [GEOG 90](#): Research in Geography - [Lopez](#) (6B)

Below the list, there is a "SHARE" section with social media icons for Twitter, Email, and a general share icon. A horizontal line separates the "FALL 2018" section from the "WINTER 2019" section. The "WINTER 2019" section lists the following courses:

- [GEOG 2/INTS 18](#): Global Health and Society - [Butterly/Adams](#) (2A)
- [GEOG 6/INTS 16](#): Introduction to International Development - [Fox](#)
- [GEOG 8](#): Life in the Anthropocene - [McKeon](#) (12)
- [GEOG 9](#): Climate Change and the Future of Agriculture - [Winter](#) (11)
- [GEOG 11](#): Qualitative methods and Research Process - [Neely](#) (2A)
- [GEOG 28/LATS 40/SOCY 48](#): Immigration, Race & Ethnicity - [Wrig](#)
- [GEOG 44/ENVS 44](#): Environment and Politics in Southeast Asia - [Sr](#)
- [GEOG 51/EARS 65](#): Remote Sensing - [Palucis](#) (10A)
- [GEOG 54](#): Geovisualization - [Chipman](#) (10)
- [GEOG 61](#): Global Movements: Migrants, Refugees, and Disporas - [W](#)

Another horizontal line separates the "WINTER 2019" section from the "SPRING 2019" section. The "SPRING 2019" section lists the following course:

- [GEOG 1](#): Introduction to Human Geography - [Lopez](#) (2)

# GIS AT DARTMOUTH: SOFTWARE & DATA

- Commonly used Desktop GIS Software:
  - ArcGIS Desktop (windows only, Mac users can use through Parallels or Bootcamp virtual machines running windows)
  - QGIS (Open-source, runs on a Mac)
  - ArcGIS Pro (new software from ESRI, with optimizations for 3-D viewing)
- Common web-based mapping & GIS tools
  - ArcGIS Online
  - Carto (formerly CartoDB), online mapping platform
  - Google Maps – sign up for a gmail account, allows you to make your own maps on top of Google Maps basemaps and imagery
  - Google Earth Pro
- Other
  - R Statistical package with GIS libraries
  - Python with GIS libraries
- Some data resources, producers & warehouses
  - <https://researchguides.dartmouth.edu/gisdata/usdata>
  - [www.data.gov](http://www.data.gov) and <https://www.data.gov/geospatial/>
  - <https://www.openstreetmap.org/> and <https://www.openstreetmap.org/export>
  - State government GIS clearinghouses
  - Social Explorer, Simply Map, PolicyMap, American Factfinder, Census Bureau

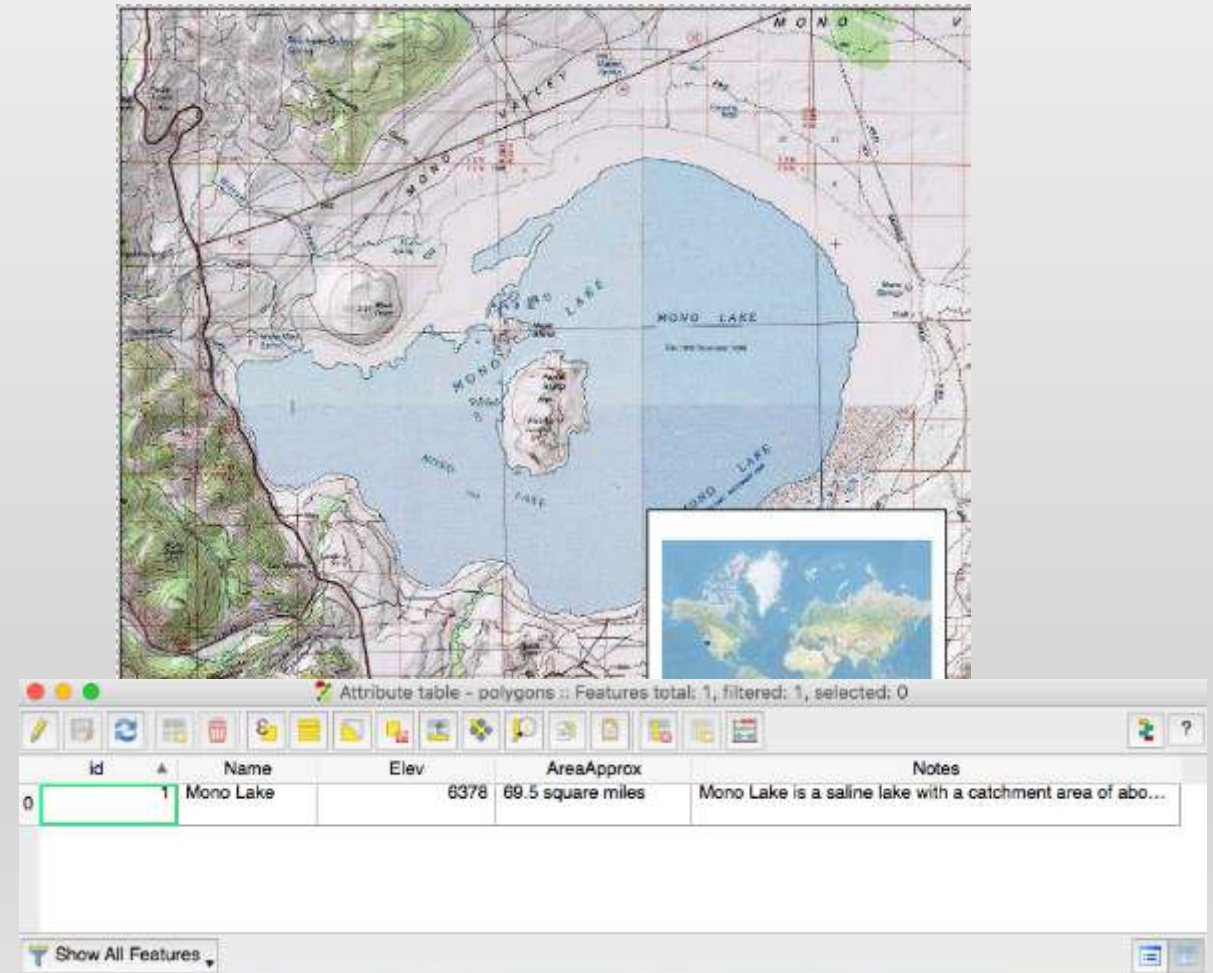
# WHAT IS GIS?

- Geographic Information Systems allow us to interactively work with geographic data.
- This includes creating, editing, displaying, analyzing and printing geographic information
- Most GIS's allow for both spatial viewing in a map and tabular viewing in a database tables.
- Some basic GIS work can be done in a web browser
- More advanced GIS analysis and editing can be done with Desktop GIS software on basic PC's and Mac's.
- Often GIS research and analysis requires very powerful desktop computers or high-performance servers.



# WHAT IS GIS?

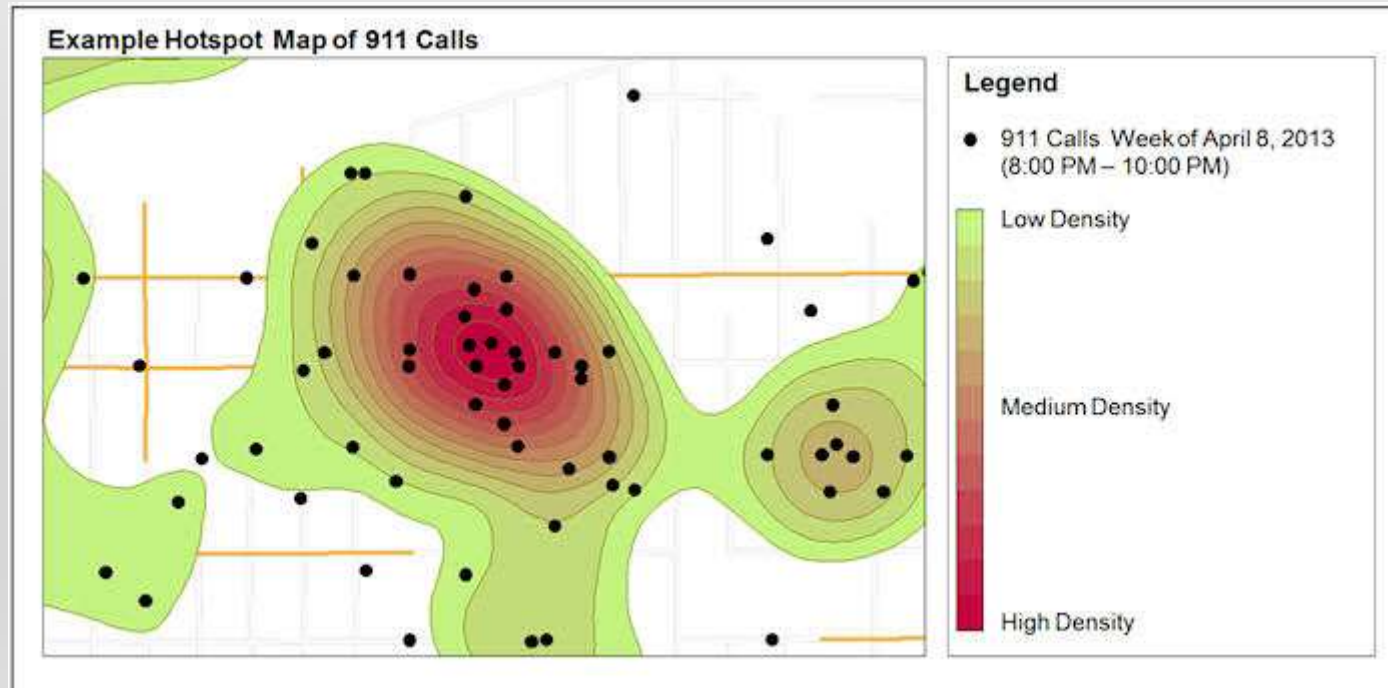
- view and analyze data worldwide at a variety of scales, zooming and panning, using digital map layers





# WHAT IS GIS?

- GIS maps and data are sometimes called smart maps, location intelligence, geospatial intelligence
- With good data, GIS's can be used to answer research questions, provide new insight, assist in navigation

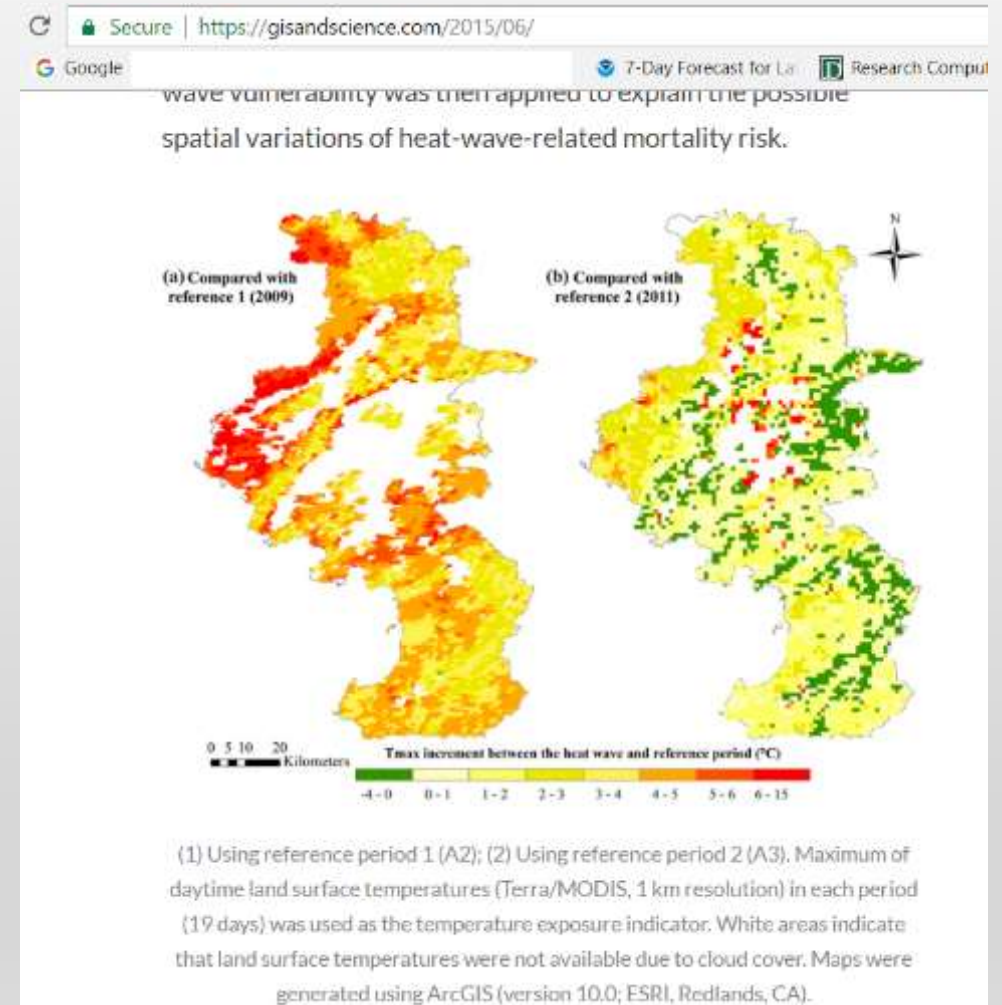


# WHAT IS GIS?

## RESEARCH JOURNAL PUBLICATIONS

Selected journals:

- *Applied Geography*
- *American Geophysical Union EOS Transactions*
- *Transactions in GIS*
- *Remote Sensing*
- *International Journal of Geographical Information Science*
- *Geographical Analysis*
- *Journal of Biogeography*
- *Journal of Economic Geography*
- *Cartographica*



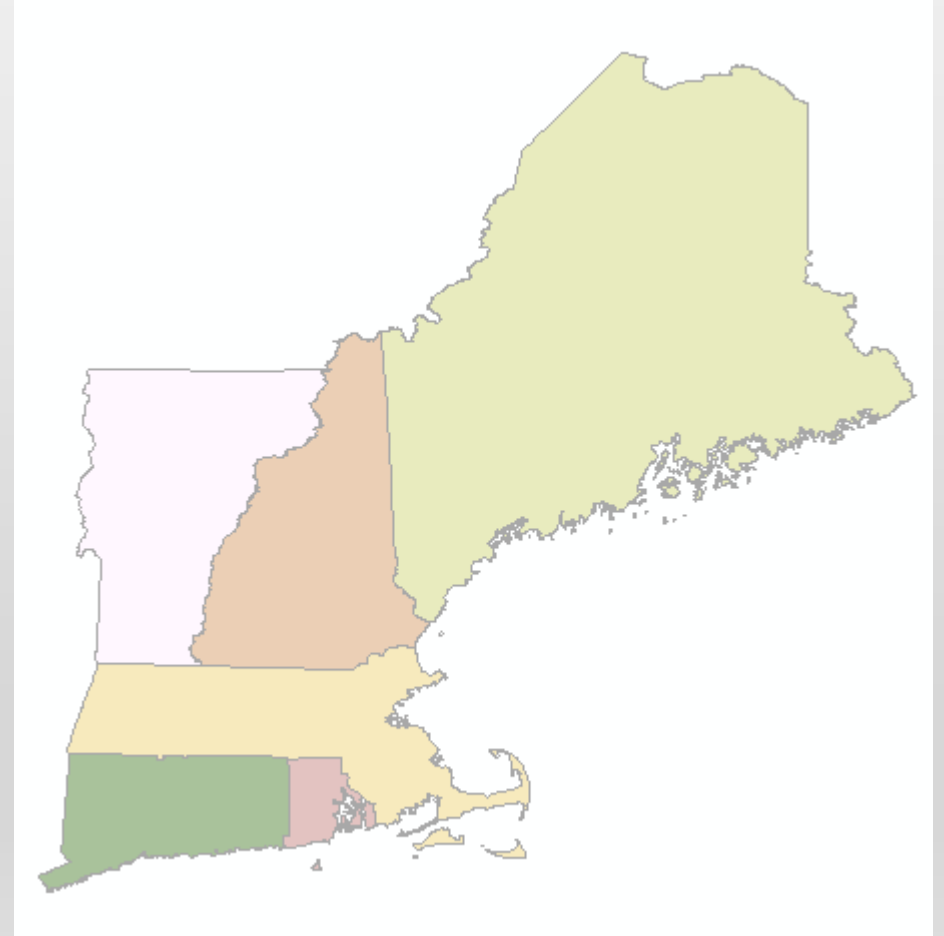
# TYPES OF GIS DATA

- Basic Data Types and Formats:
  - Spatial:
    - Vector
    - Raster
  - Tabular
- Common Data File Formats
  - Vector: Geodatabase, Shapefile, KML, KMZ, xyz,
  - Raster: IMG, TIFF, JPEG, GRID
  - Tabular: Excel, database tables, csv

# TYPES OF GIS DATA: VECTOR

Shapes, boundaries and regions can be digitally represented by polygons in a geographic model of reality.

- Polygons

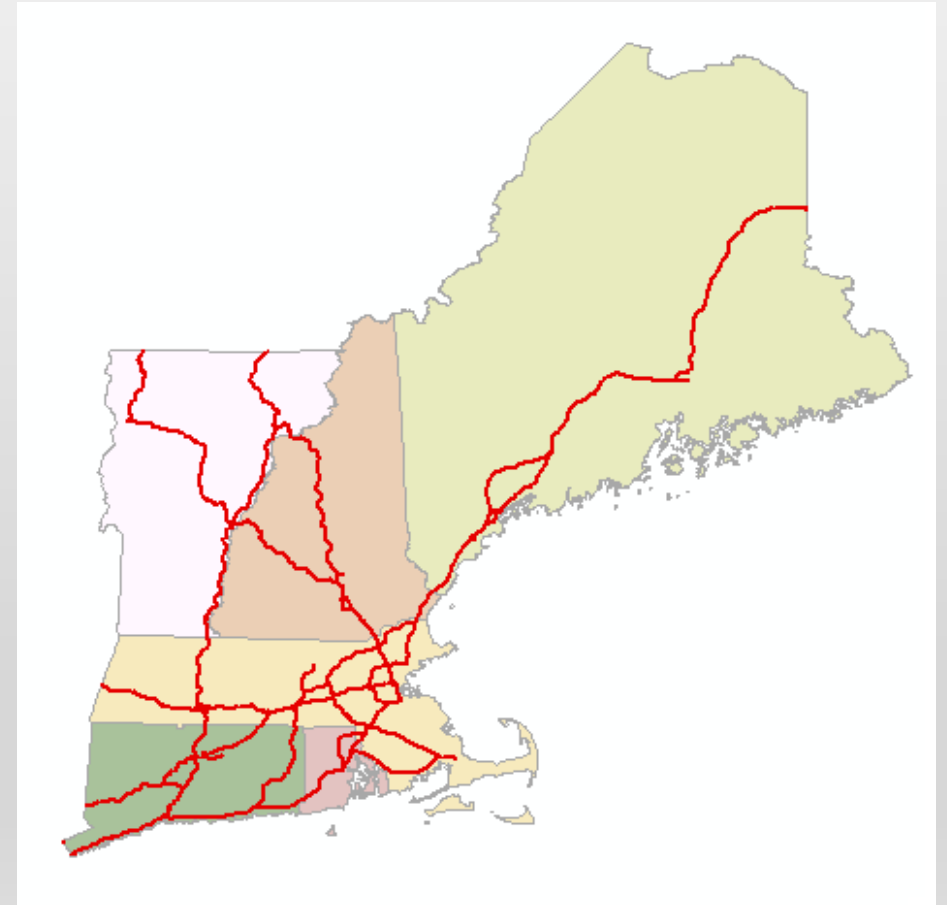


# TYPES OF GIS DATA: VECTOR

Linear features can also be represented using GIS software

Map layers and features can be placed on top of one another to create maps and perform geospatial analysis

- Polygons
- Lines



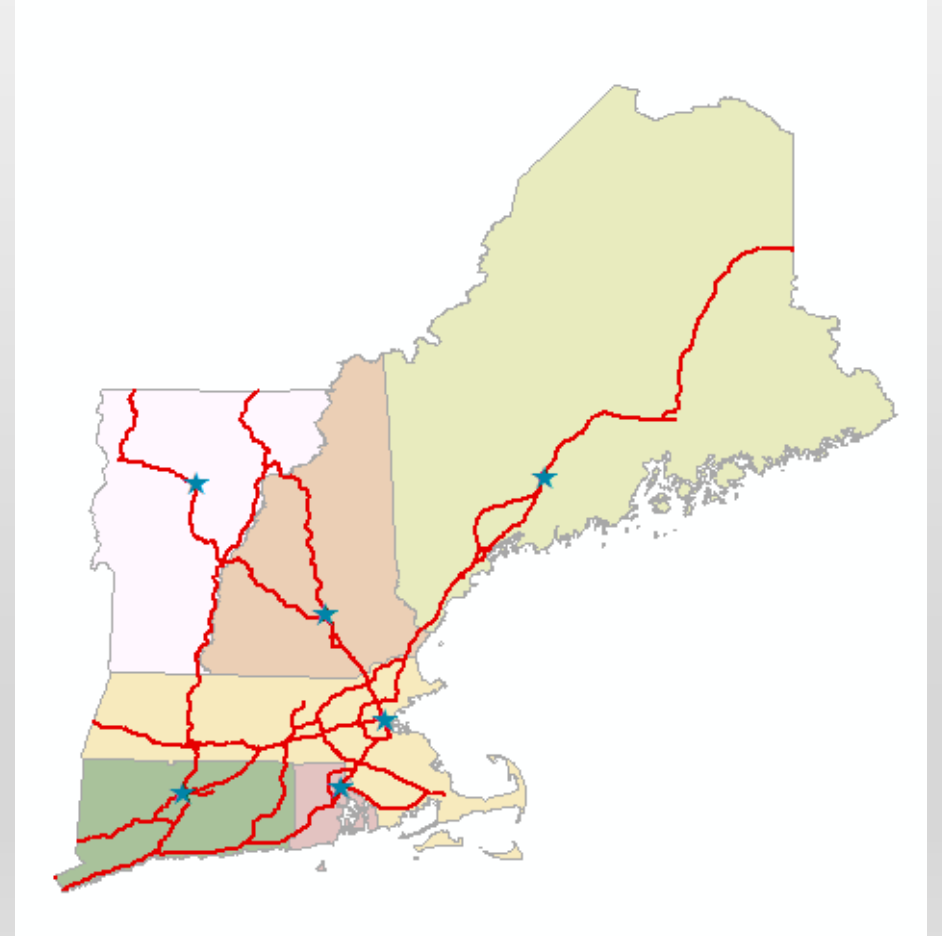
# TYPES OF GIS DATA: VECTOR

An individual point, line or polygon is known as a “Feature”

Features such as state capitals and cities can be represented by points

Notice how the GIS system uses a “stack” of map layers. The layers are also sometimes known as themes.

- Polygons
- Lines
- Points



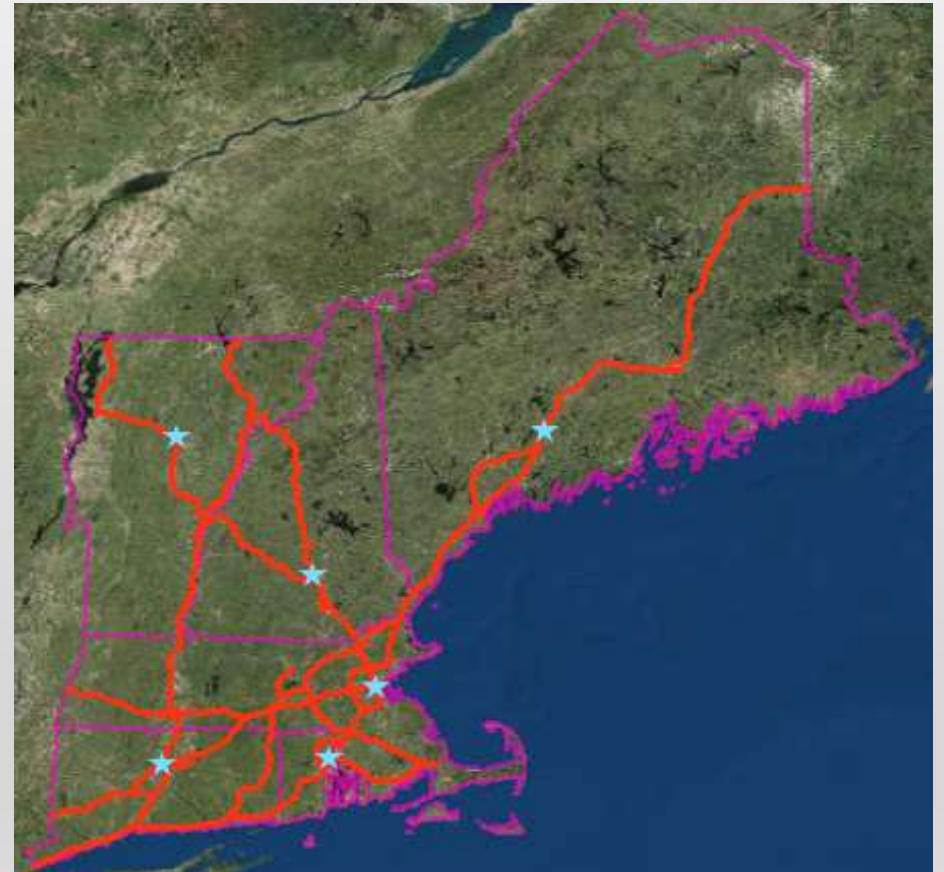


# TYPES OF GIS DATA: VECTOR & RASTER

Raster Datasets can be used for background imagery, land use, elevation models

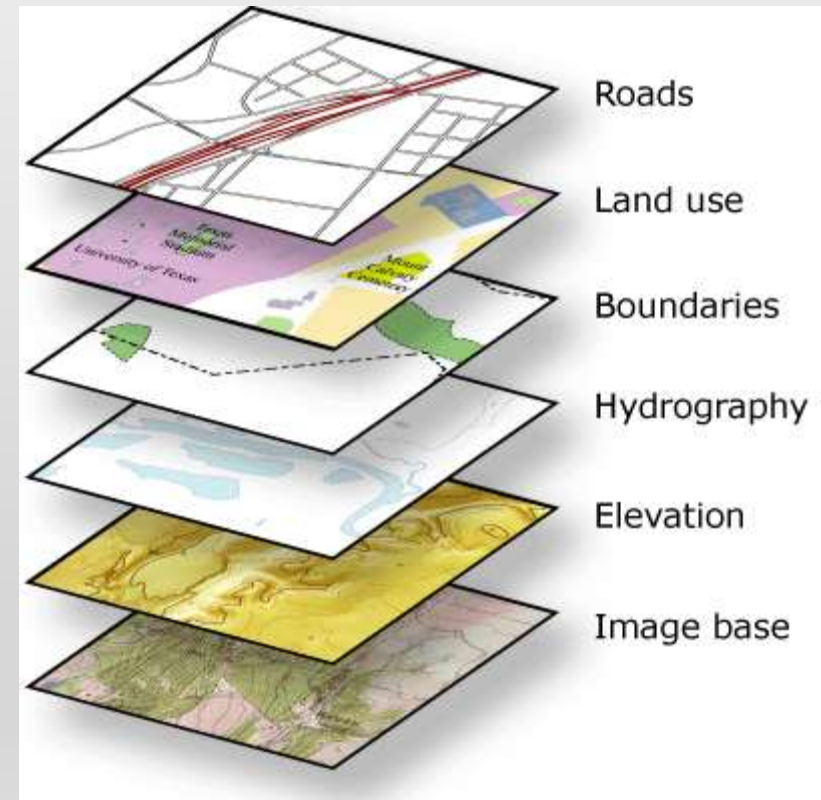
Examples include satellite imagery, aerial photography, other raster or pixel-based data sets

- Polygons
- Lines
- Points
- Raster



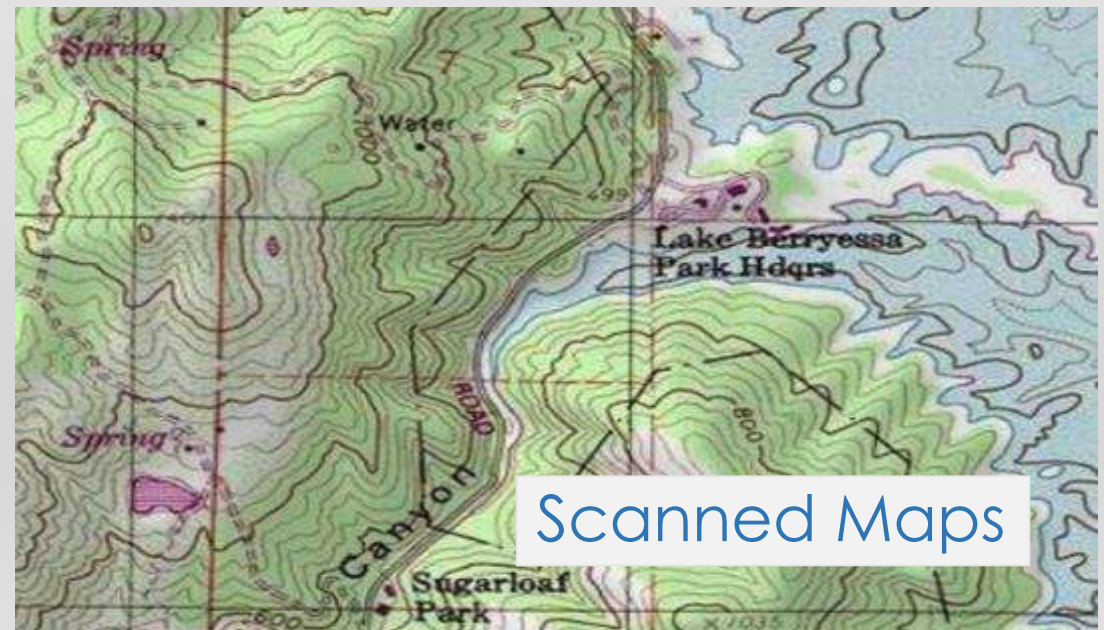
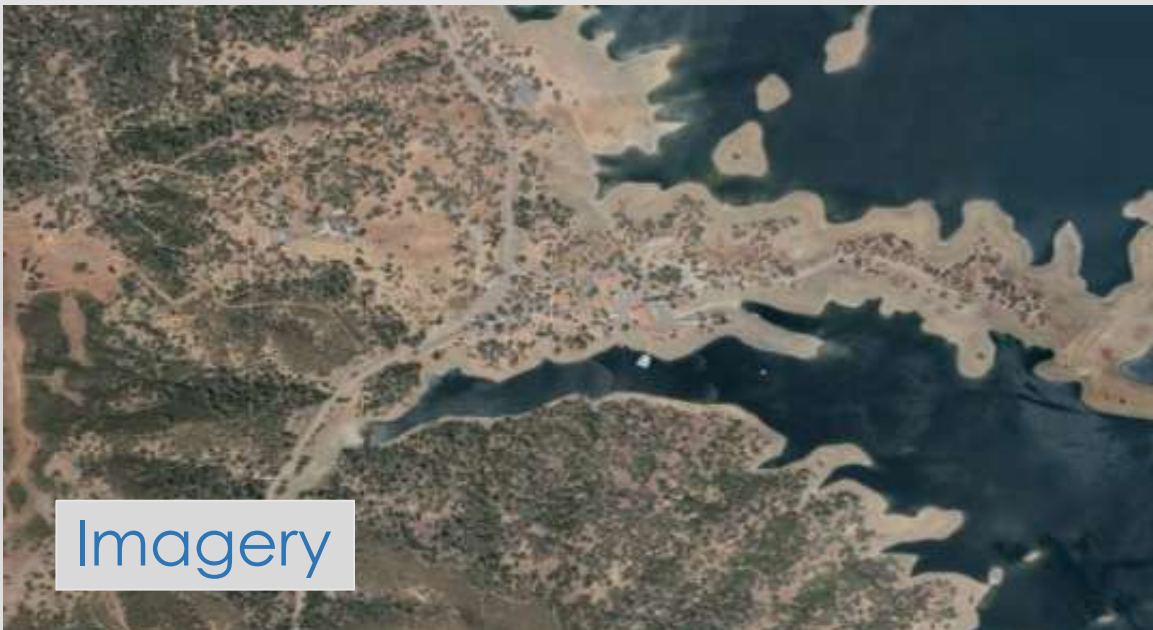
# TYPES OF GIS DATA: GIS AS A “STACK OF MAPS”

- GIS systems handle multiple layers each with many features within each layer
- Layers can have independent symbols
- Layers can be partially transparent
- Analysis can be done within layers, or with multiple layers
- Layers are MODELS of observations made in the real world



# TYPES OF DATA: RASTER

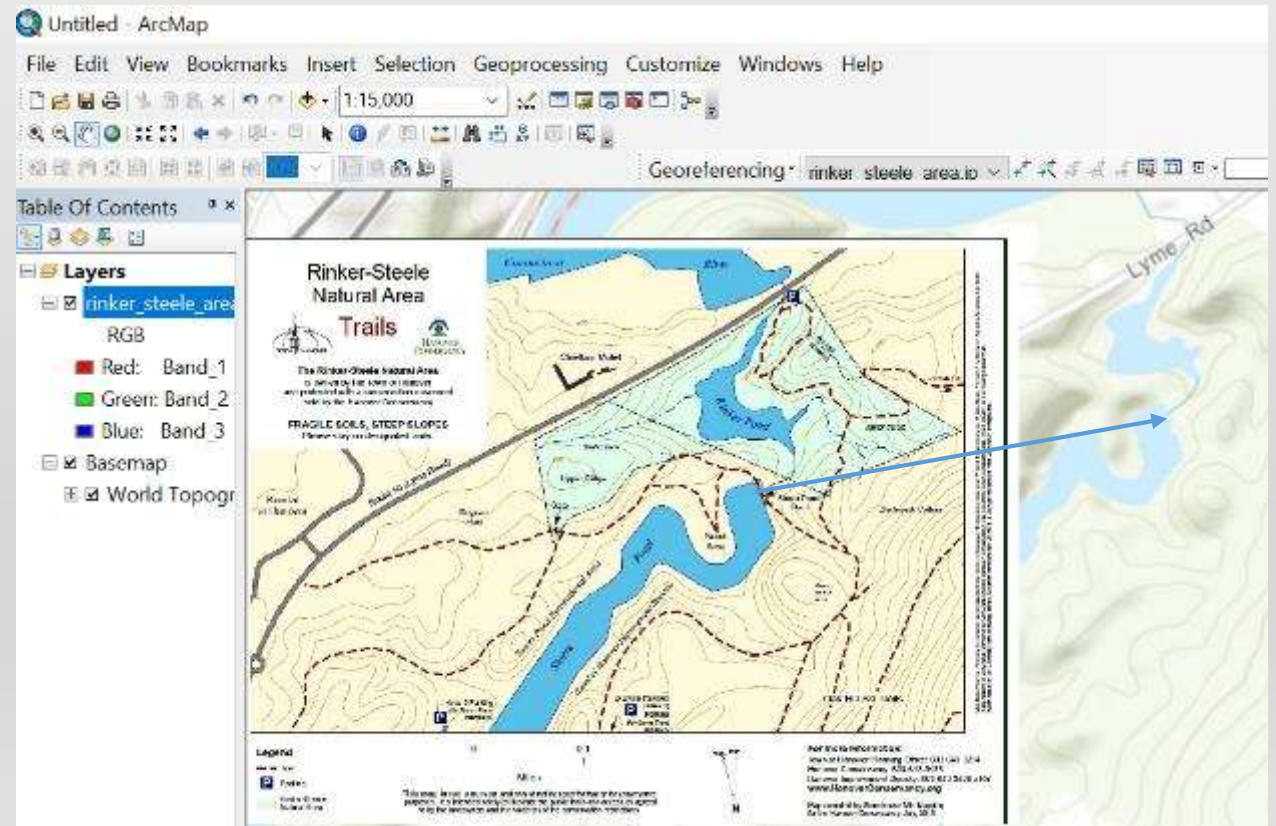
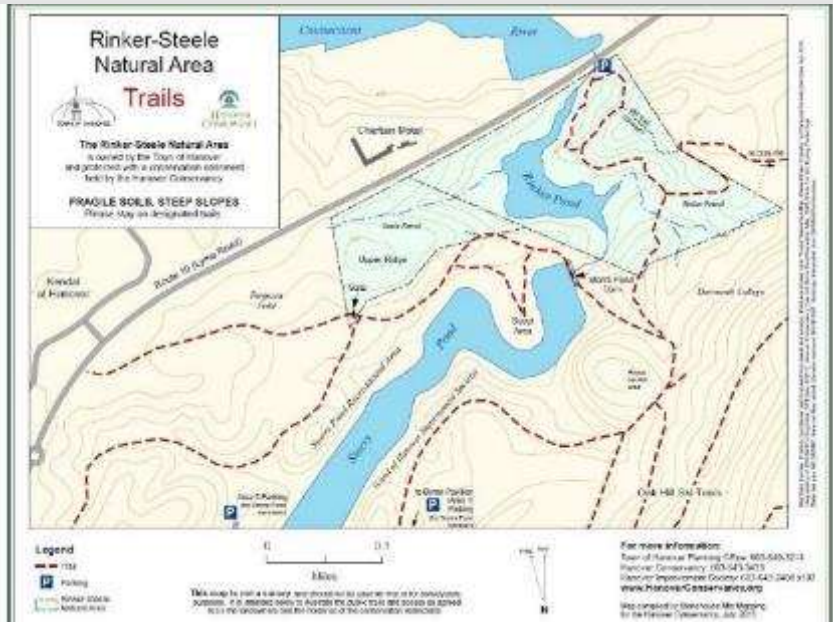
- Imagery, elevation models, scanned maps, surfaces
- A regular grid of cells in rows and columns
- Each cell has a value



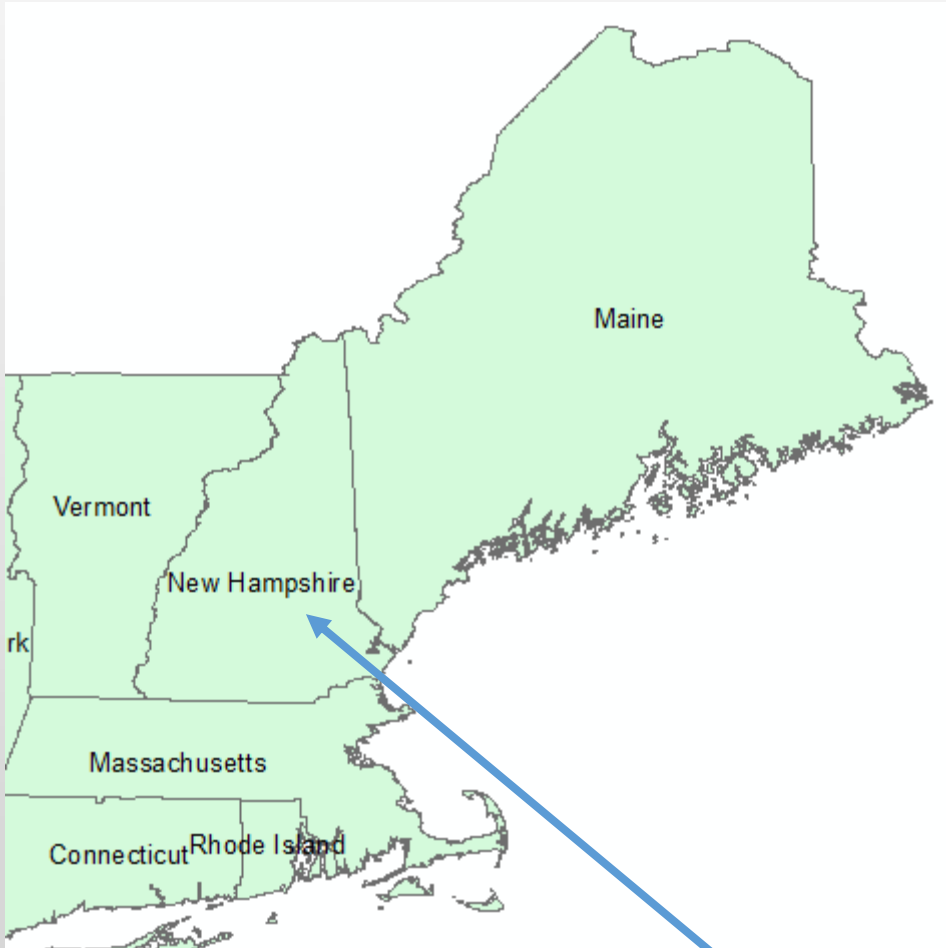


# TYPES OF DATA: RASTER

- Scan historical maps, paper maps
- “Georeference” to base map data
- Generate new GIS data based on features from paper maps



# TYPES OF GIS DATA: VECTOR ATTRIBUTES



- Part of the “INFORMATION SYSTEM” behind the geographic data
- Much of the power of GIS is the ability to store attributes related to geographic features.
- This example shows the attributes of the New England States polygons: State Name, Abbreviation, “FIP” code, year joining the U.S., population and square miles
- Attribute tables are similar to relational database tables or well-structured spreadsheets

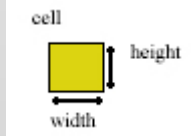
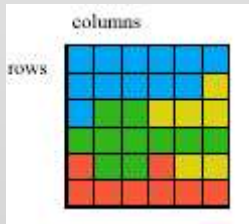
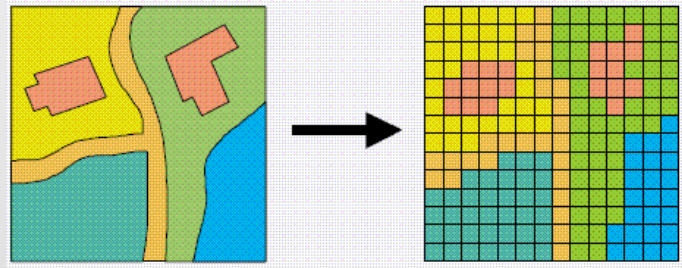
Table

statesp010g

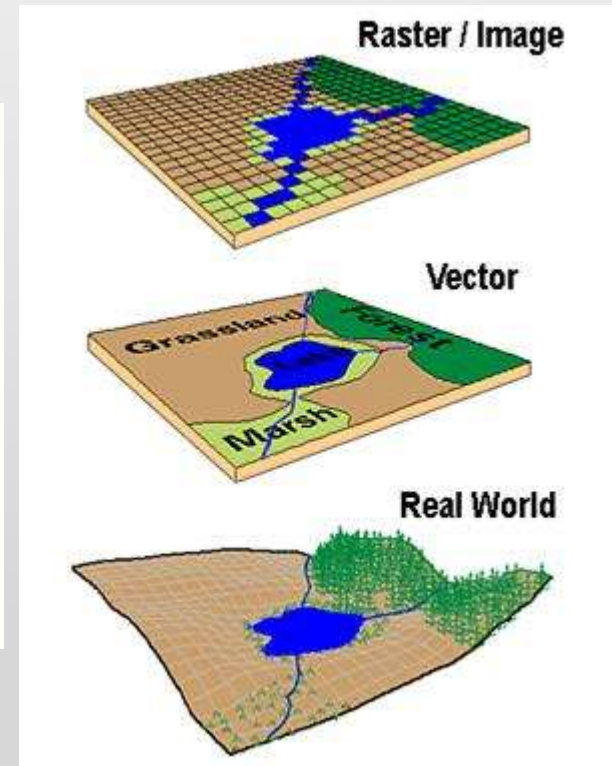
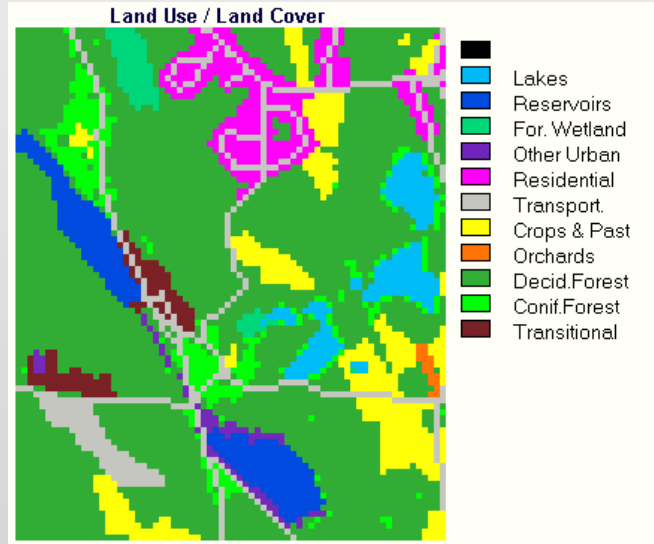
	FID	Shape *	NAME	STATE_ABBR	STATE_FIP	YEAR_ADM	POP	SQ_MILE
	23	Polygon	Vermont	VT	50	1791	625741	9619.1
	35	Polygon	Connecticut	CT	09	1788	3574097	4972.2
	39	Polygon	Massachusetts	MA	25	1788	6547629	8113
	47	Polygon	Rhode Island	RI	44	1790	1052567	1084.6
	53	Polygon	Maine	ME	23	1820	1328361	32485.4
	56	Polygon	New Hampshire	NH	33	1788	1316470	9258.8

# TYPES OF DATA: RASTER DATASET STRUCTURE

- Raster structure and attribution



Value	Count	Landuse
1	12	Water
2	8	Agriculture
3	6	Residential
4	6	Industrial





# TYPES OF GIS DATA & WORKFLOWS

- Example of GIS workflow:
  - Development of a research question
  - Scope of work for the proposal and data needs / data gap assessment
  - Data acquisition and input
  - Data management
  - GIS Data analysis & statistical analysis
  - Data output: Maps, new GIS datasets, journal publications, conference posters, reports, figures
- GIS Data layers are digital representations of geographic models
- When properly created, the layers can be overlaid, similar to using a base map with transparent overlay maps
- Data can include both “tabular” and “spatial” data

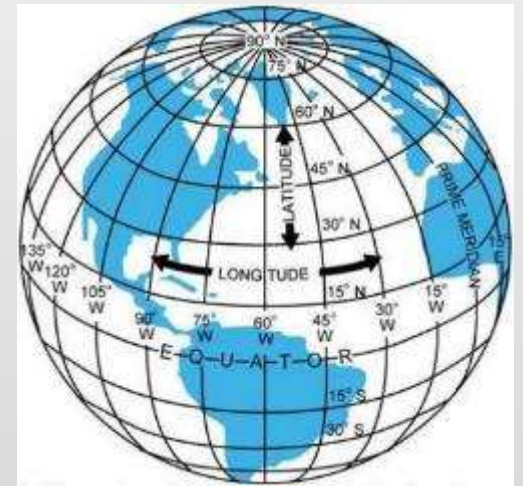
# TYPES OF GIS DATA & WORKFLOWS

- Non-geographic tabular data can often be associated with geographic data
- Tables, such as Excel, CSV text files, database tables from Access or Oracle, can be used in GIS software
- Tables can be joined with existing spatial data files by a common attribute, such as state name or zip code
- Tables with latitude and longitude from a global positioning system device (GPS) can be imported in to GIS and placed on a map
- Geocoding is a process where well-formatted street addresses can be joined to a geocoding service based on a well-formatted street network

	A	B	C	D	E	F	G	I	J
1	Company Name	Executive First	Executive La	Address	City	State	ZIP Code	Latitude	Longitude
2	Boston Tea Stop			54 Jfk St # 1	Cambridge	MA	2138	42.372008	-71.120581
3	Central Brew Cafe & Espresso			350 Massachusetts Ave	Cambridge	MA	2139	42.36236	-71.099692
4	Dado Tea	Jenny	Song	955 Massachusetts Ave # 4	Cambridge	MA	2139	42.369155	-71.109828
5	Dado Tea 50 Church Street	Jennie	Song	50 Church St	Cambridge	MA	2138	42.37385	-71.120417
6	Fort Point Tea Co	William G J	Walsh	26 Alewife Brook Pkwy	Cambridge	MA	2140	42.40228	-71.134796
7	Peet's Coffee & Tea	Janice	Zazinky	100 Mount Auburn St	Cambridge	MA	2138	42.372876	-71.121697

# REFERENCING DATA TO THE EARTH: DATUMS, MAP PROJECTIONS, COORDINATE SYSTEMS

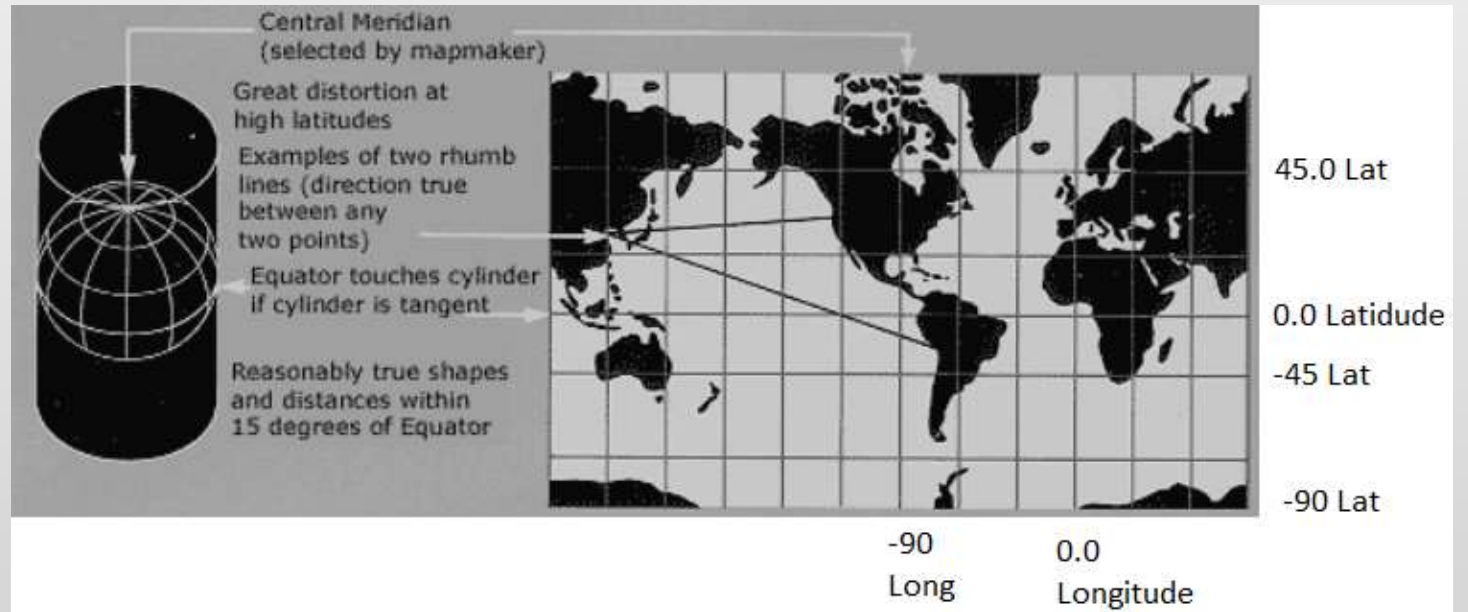
- Geographic Information Systems rely on reference system for data input, display and analysis
- Locations on the earth's surface can be represented by a geographic coordinate system that includes an approximation of the earth's surface, and a coordinate pair (latitude and longitude)
- A “datum” is a mathematical model of the earth's surface
- A “map projection” allows us to project all or part of the earth's (spherical) surface on to a flat surface such as a computer screen or a piece of paper
- A “coordinate system” is used to identify locations based on the datum and map projection



# REFERENCING DATA TO THE EARTH

## DATUMS, MAP PROJECTIONS & COORDINATE SYSTEMS

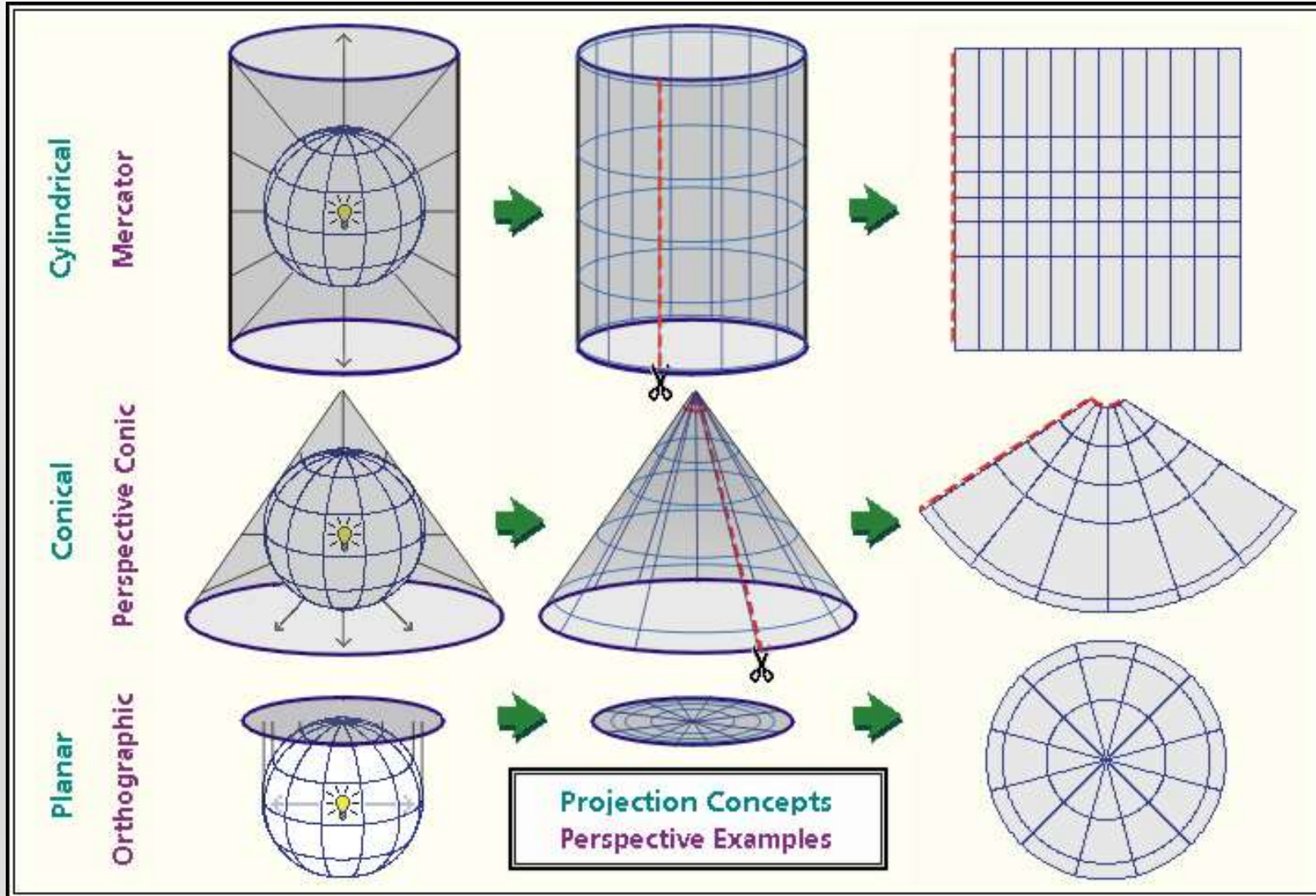
- To project a 3-dimension spheroid in to two dimensions (paper, computer screen, etc), at least some of the following will be distorted by the map projection:
  - Area
  - Direction
  - Shape
  - Distance



Coordinate systems can use other units, such as feet and meters

Read more and see more at <http://egsc.usgs.gov/isb//pubs/MapProjections/projections.html>

# REFERENCING DATA TO THE EARTH DATUMS, MAP PROJECTIONS & COORDINATE SYSTEMS





# REFERENCING DATA TO THE EARTH MAP PROJECTIONS



*Mercator Projection*



*Gall-Peters Projection*



*Miller Cylindrical Projection*



*Mollweide Projection*



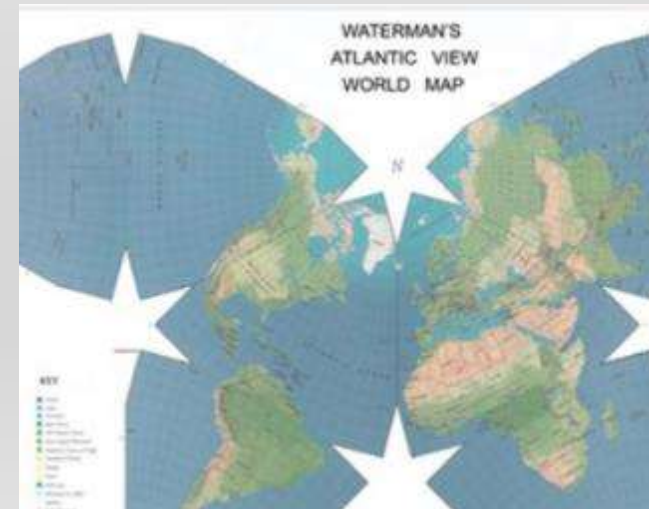
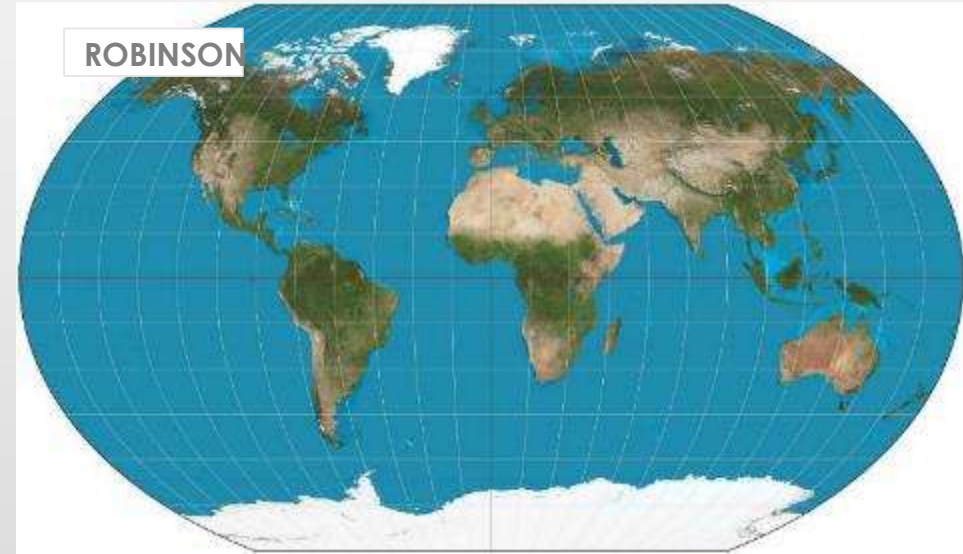
*Goode's Homolosine Equal-area Projection*



*Sinusoidal Equal-Area Projection*



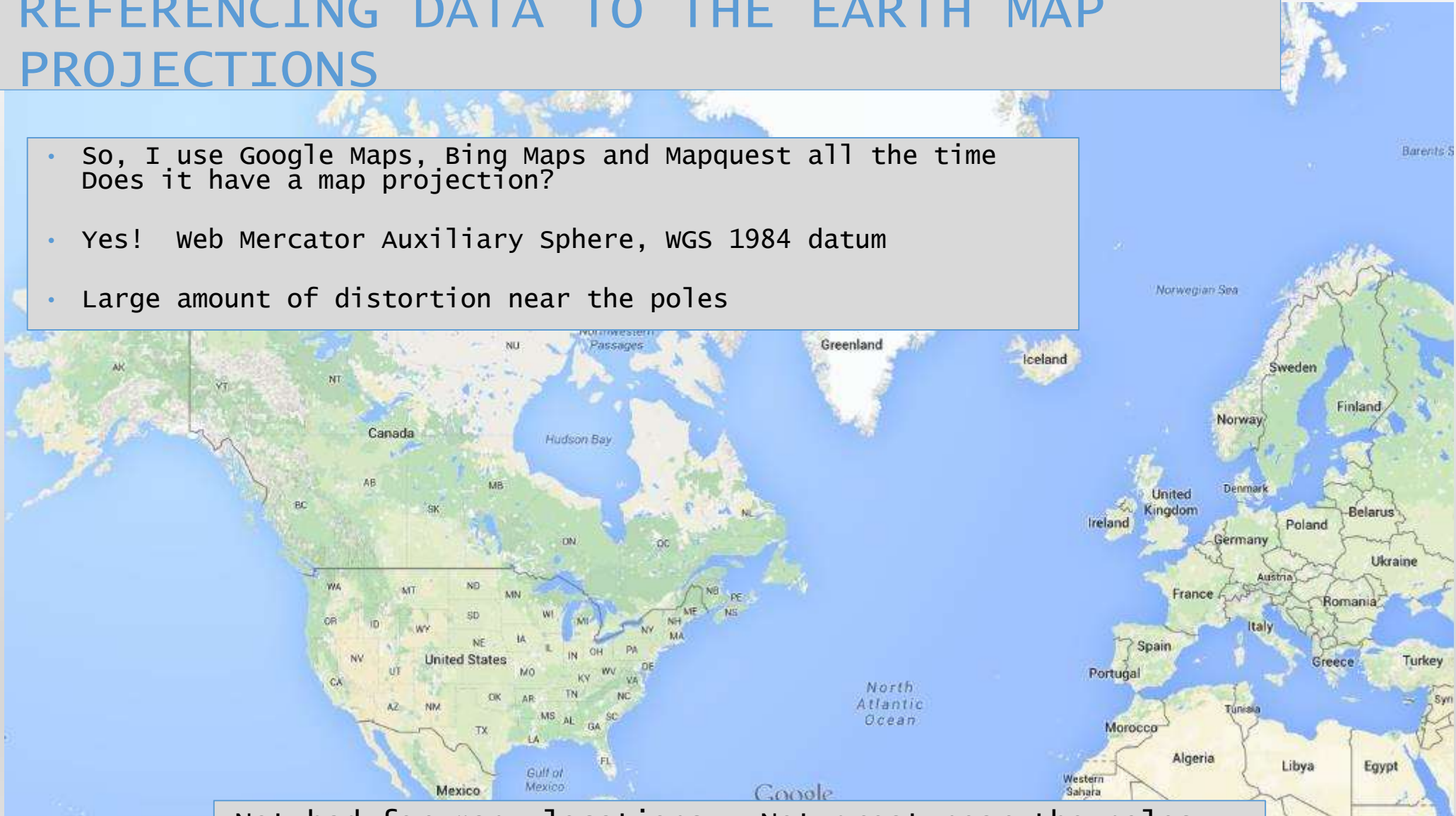
*Robinson Projection*





# REFERENCING DATA TO THE EARTH MAP PROJECTIONS

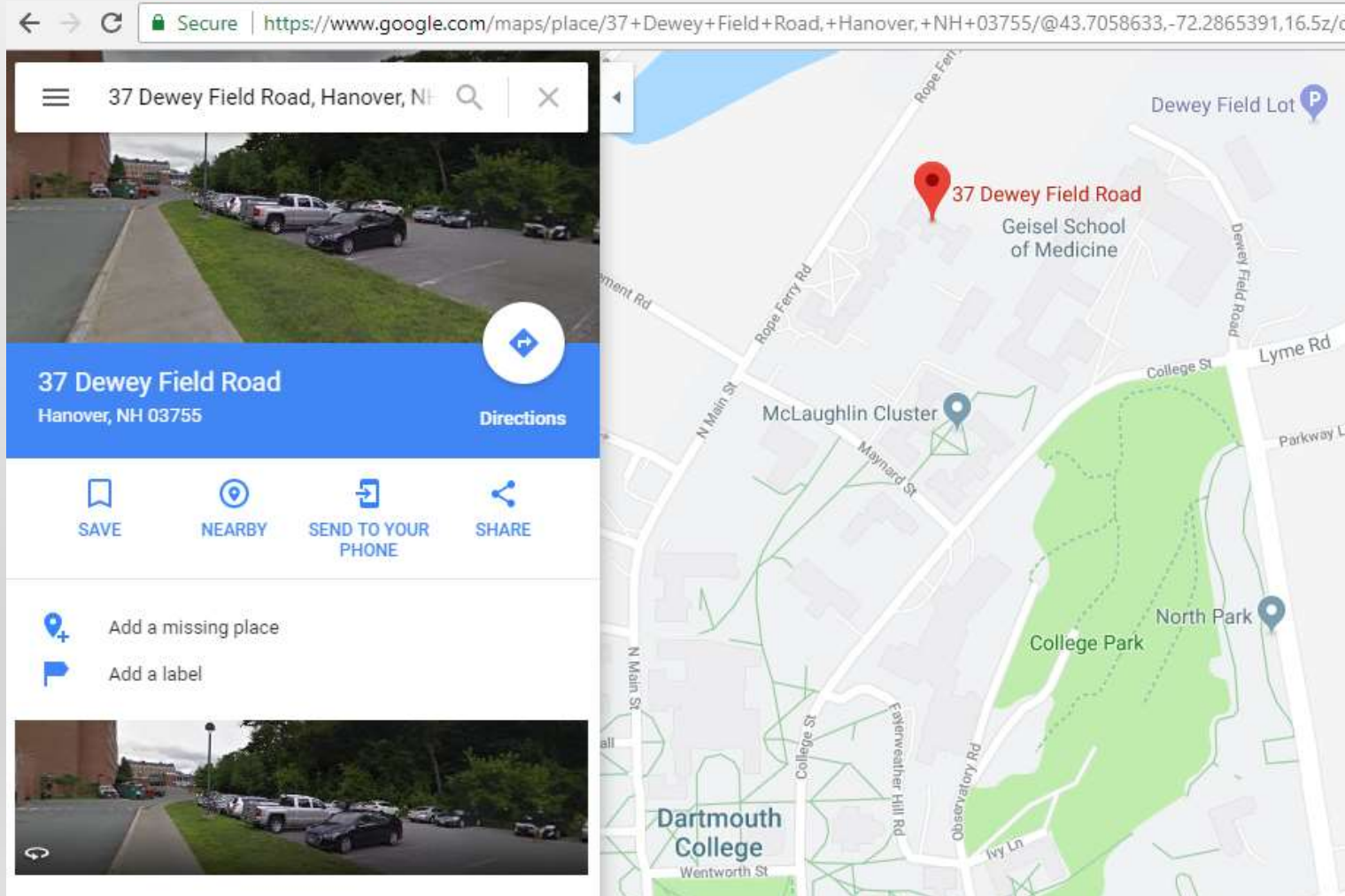
- So, I use Google Maps, Bing Maps and Mapquest all the time  
Does it have a map projection?
- Yes! Web Mercator Auxiliary Sphere, WGS 1984 datum
- Large amount of distortion near the poles



Not bad for many locations. Not great near the poles

# REFERENCING DATA TO THE EARTH MAP

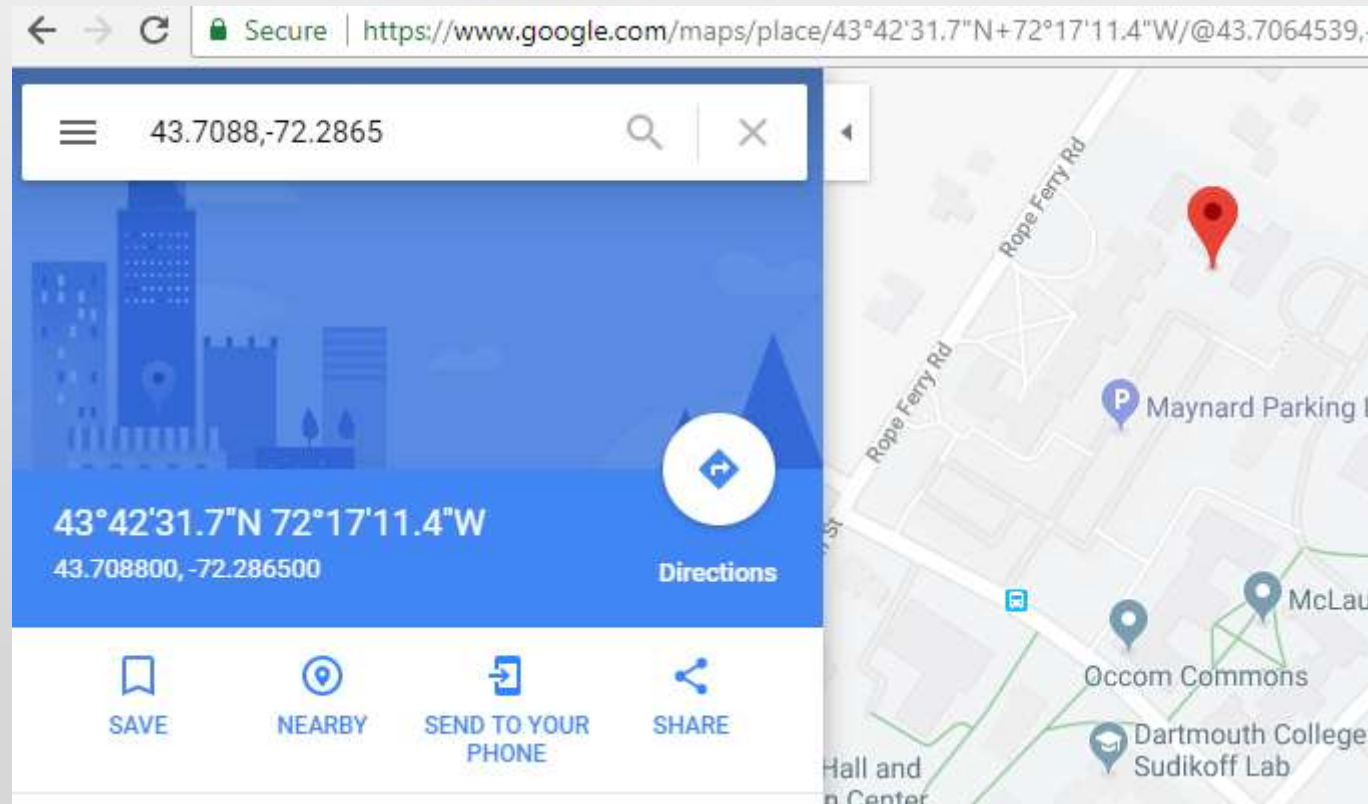
37 Dewey Field Road, Hanover, NH 03755 USA ~ 43.7088, -72.2865



Google Maps is “geocoding” the address to a map (datum, projection, coordinate system)

# REFERENCING DATA TO THE EARTH MAP

Google maps can accept latitude and longitude as input also



# WORKING WITH GIS

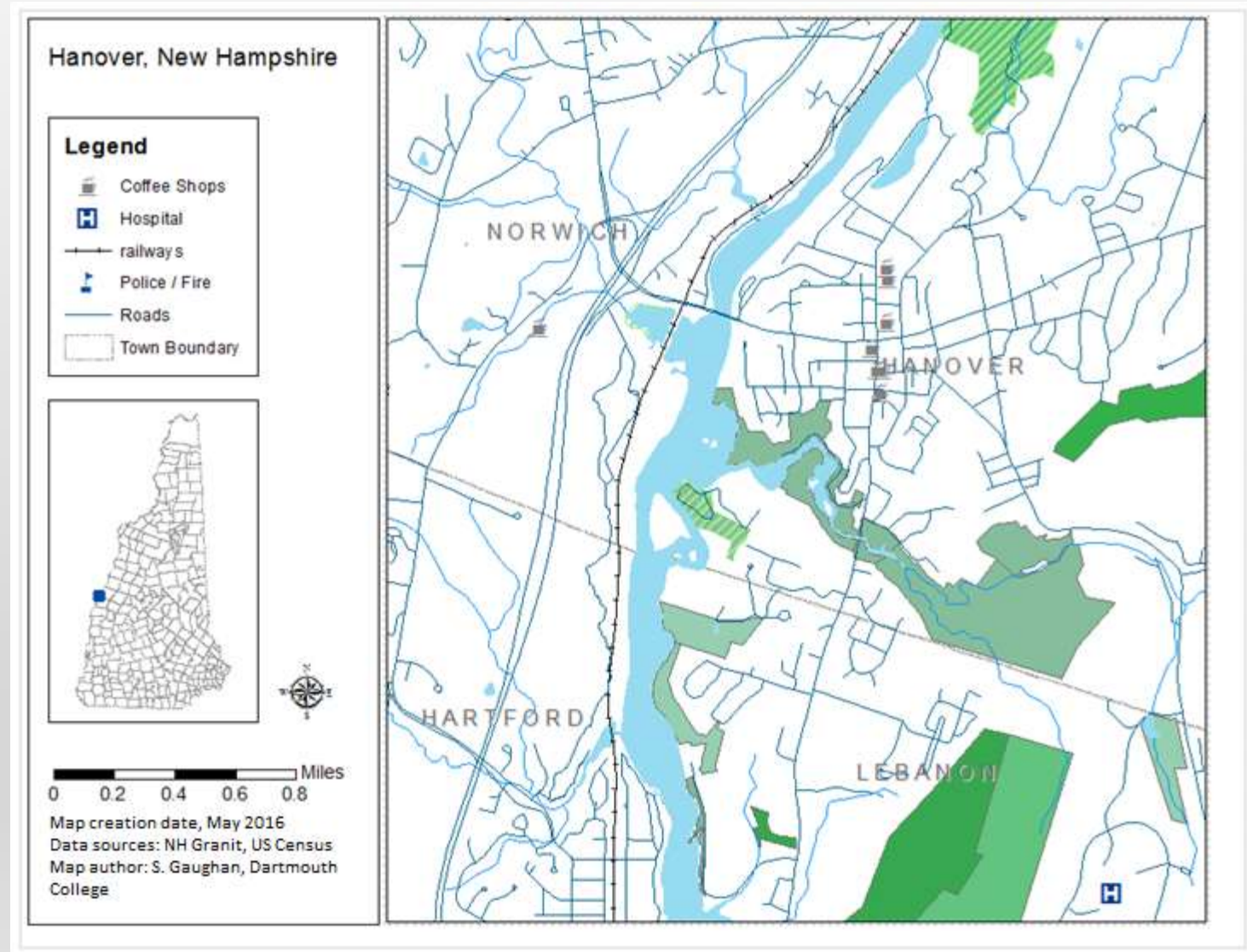
- GIS Functionality
  - View geospatial data
  - Create maps
  - View imagery
  - Analyze spatial data
    - Examples: calculate and show distance away from an object, known as a “buffer”
    - Calculate what falls inside and outside a polygon or a buffer
    - Classify imagery
  - Create 3-D models using ground elevation data and structure elevation data



# WORKING WITH GIS

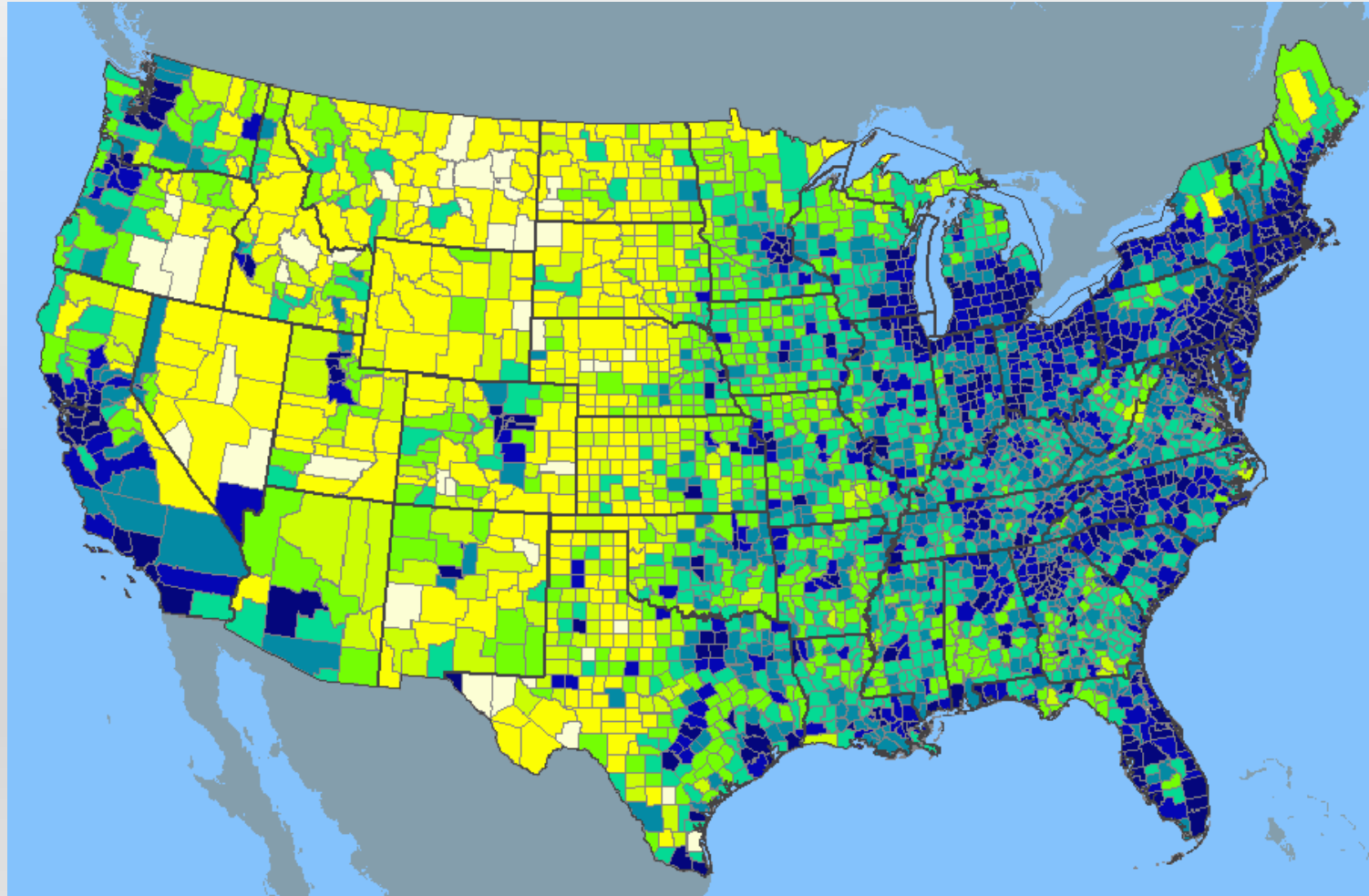
## CREATE MAPS AND VIEW GEOGRAPHIC DATA

- Note map elements



# WORKING WITH GIS CREATE MAPS

- MAP OF US POPULATION DENSITY IN 2000 BY COUNTY





# WORKING WITH GIS VIEW IMAGERY

- Imagery sources and vendors include:
  - USGS Digital Orthoquads (DOQs)
  - NOAA imagery
  - USDA National Agricultural Imagery Program (NAIP)
  - US Navy, NGA
  - Geoeye, Google, Landsat, i-cubed
  - State Agencies



# WORKING WITH GIS

## WEB, DESKTOP, DESKTOP ANALYSIS

- Web GIS systems
  - Google Maps (mymaps)
  - ArcGIS Online
  - Carto
- Desktop GIS
  - ArcGIS Desktop
  - QGIS
  - MapWindow
  - Grass GIS
- Analytical GIS tools
  - ArcGIS Desktop with ArcToolbox, Modelbuilder, Python scripting
  - R with geospatial analysis libraries
  - Python with geospatial data abstraction libraries (GDAL)

# WORKING WITH GIS

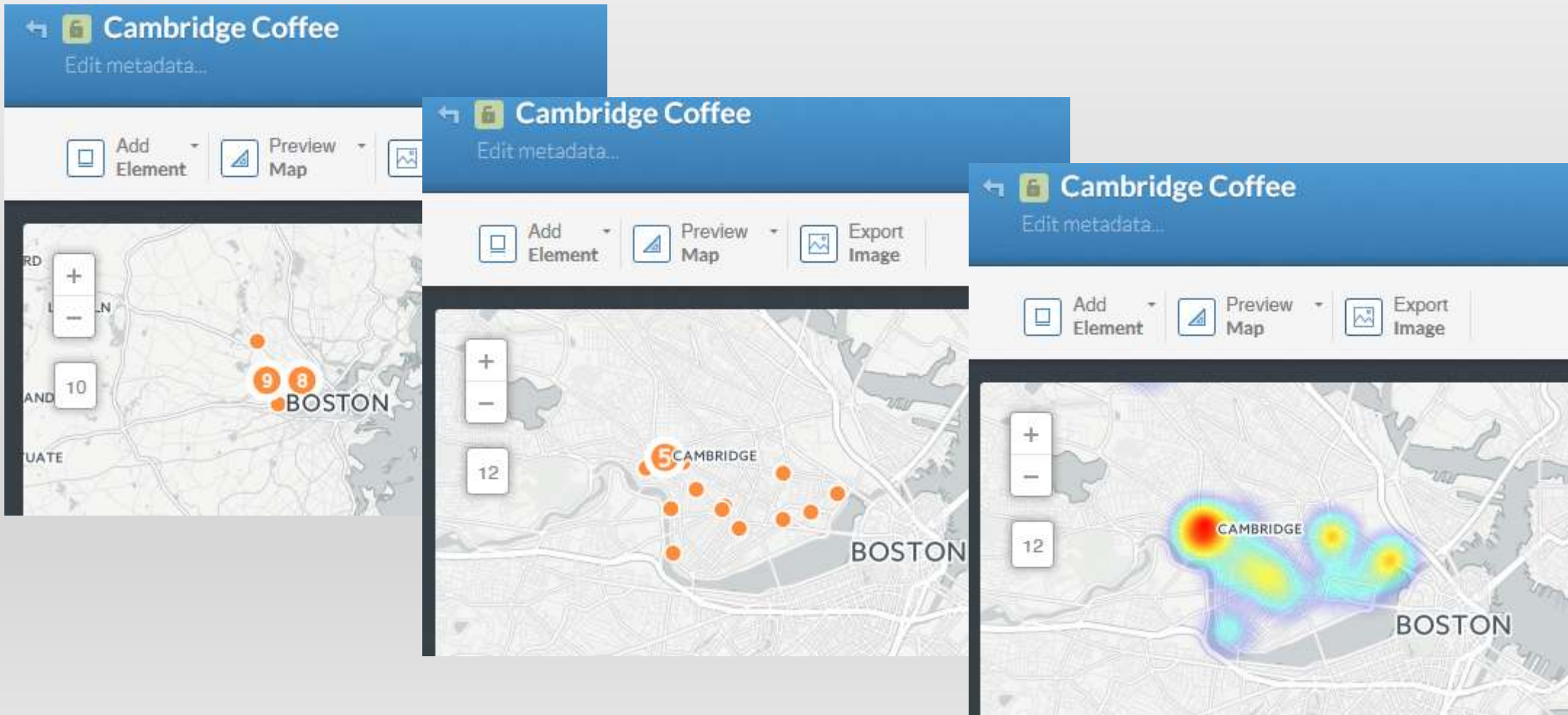
- GIS synonyms = location intelligence, smart maps, geospatial intelligence
- What question(s) are you trying to answer? What problem(s) are we trying to solve?
  - How many of the nesting sites are in the boreal forest?
  - How can I get from A to B along the road network?
  - How many of the hospitals are in flood zones?
  - Are there “hot spots” of contaminants in certain areas?

# WORKING WITH GIS

- Google Maps – quick & easy
- Google Fusion Tables
- AGOL – web-based, some analysis possible
- ESRI Maps for office
- ArcGIS Desktop
- ArcGIS Pro
- ArcGIS Enterprise / Server

# WORKING WITH GIS HEAT MAPS, CLUSTERS

- Heat map showing density of features
- Cluster symbology changes with scale



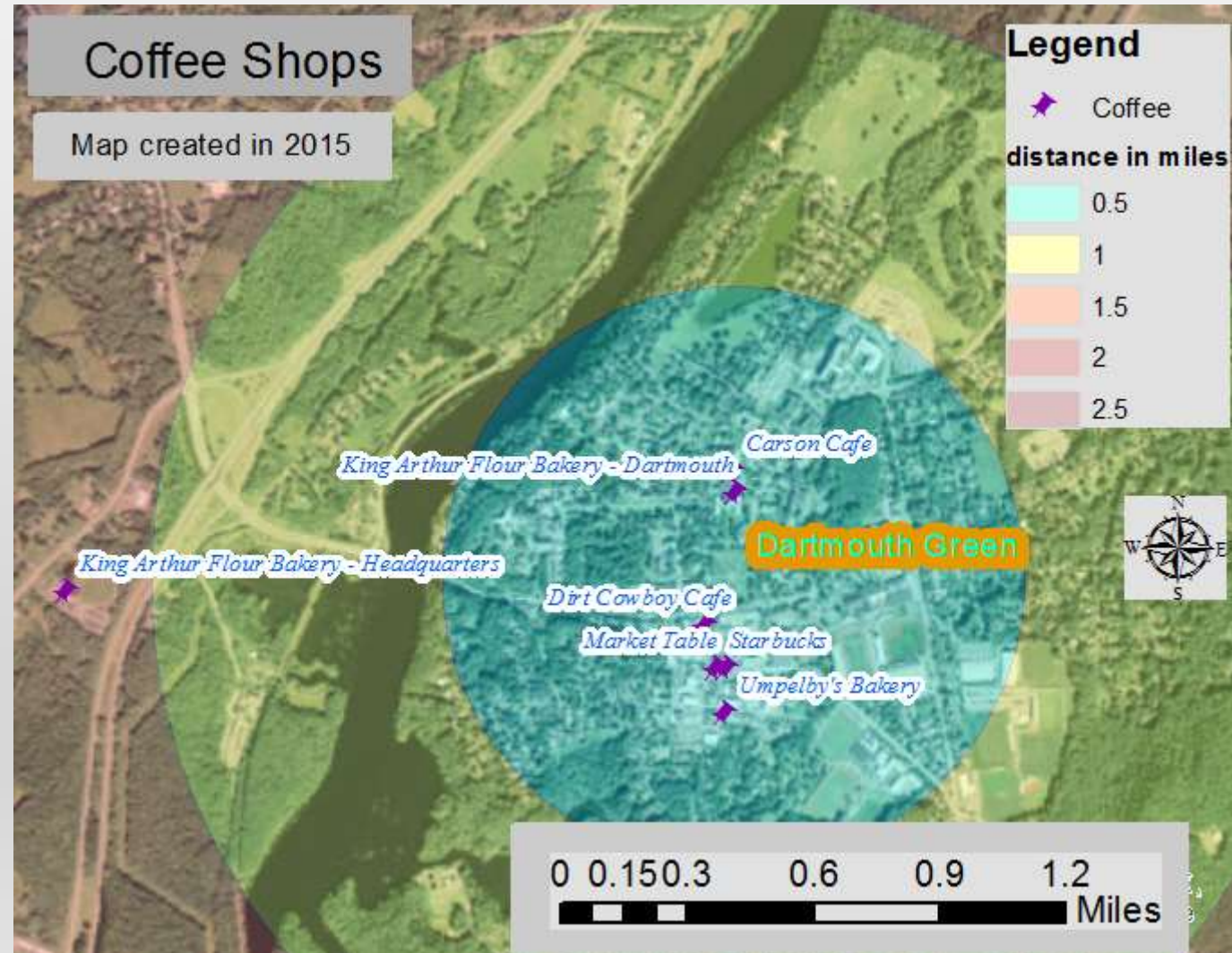
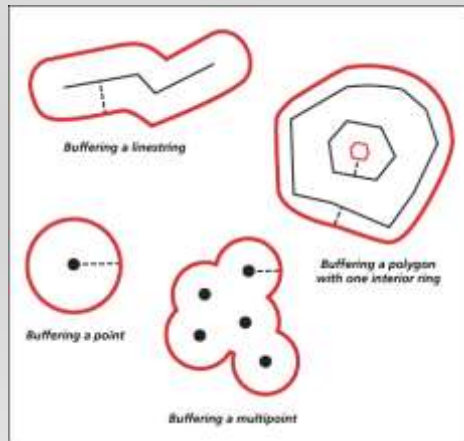


# WORKING WITH GIS: ANALYSIS

- Common GIS Analysis tools
  - Clipping data to a study area
  - Projecting data to a common spatial reference system (datum, map projection and coordinate system)
  - Map Overlay
    - Extract / Select
    - Intersect
    - Proximity
    - Spatial Join
    - Zonal Statistics
    - Raster Math
- Network analysis
- Spatial Statistics, Geostatistics
  - Hot Spots
- Interpolation
  - Surface from known or estimated points
  - Machine Learning

# WORKING WITH GIS - SPATIAL ANALYSIS -

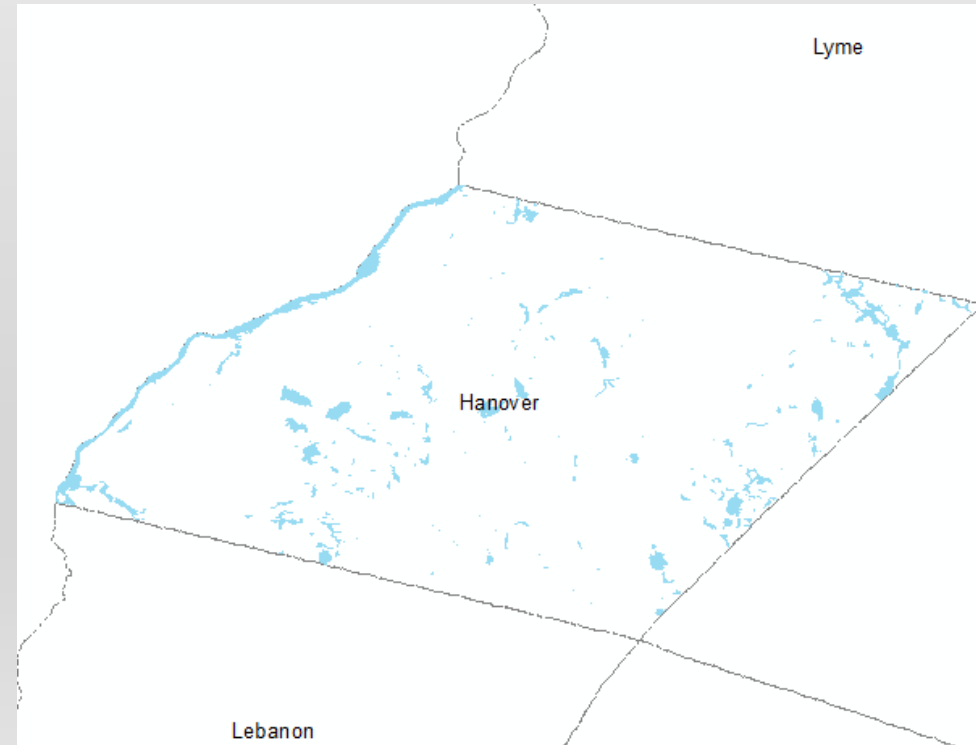
- *Spatial Analysis* includes a suite of tools, too many to mention here
- Here we see a “proximity tool” known as the Buffer tool, with the result showing distances in half-mile rings from the Dartmouth Green and the coffee shops within those rings



# WORKING WITH GIS

## - SPATIAL ANALYSIS TOOLS -

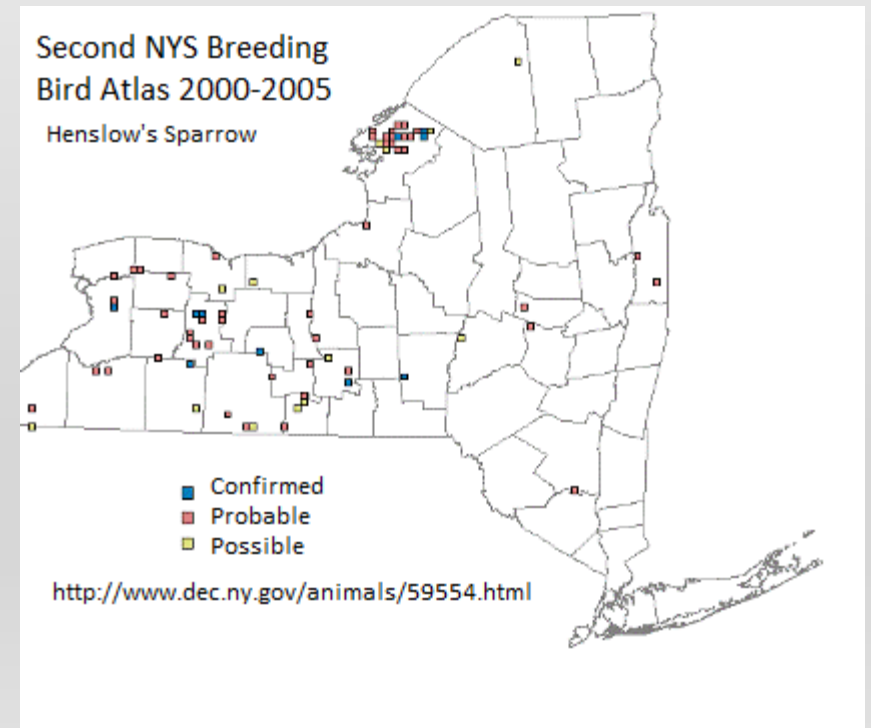
- The “Clip” tool can be used to extract a dataset to a study area, reduce overall dataset size (86,000 records statewide down to less than 500 for Hanover)
- Clipping larger datasets allows us to reduce the storage size, focus on certain areas, and perform calculations such as the “area of surface water within Hanover town boundary”



# WORKING WITH GIS

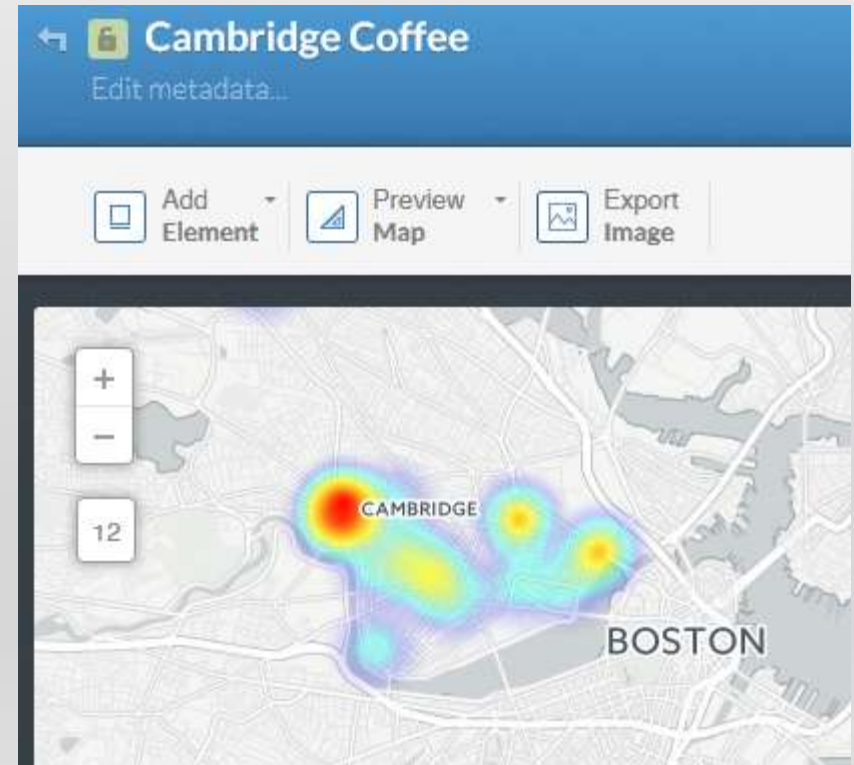
## - SPATIAL ANALYSIS & SPATIAL STATISTICS -

- Perform Data Queries and Answer Research Questions: analyze spatial distributions, patterns, relationships
- What percent occurrence of nesting sites within 500 feet of deciduous forests?
- What percent of the population lives within twenty miles of a farmers' market?
- What would be a good site for a new neighborhood park?
- What is the average number of health centers per square mile in the state?



## WORKING WITH GIS SPATIAL STATISTICS

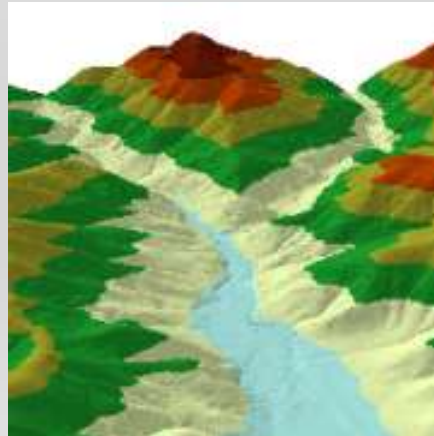
- Proximity Analysis
- Hotspots and Density Analysis
- Minimum and Maximum values
- Surface creation and analysis
- Focal window analysis
- Heat Map Representations





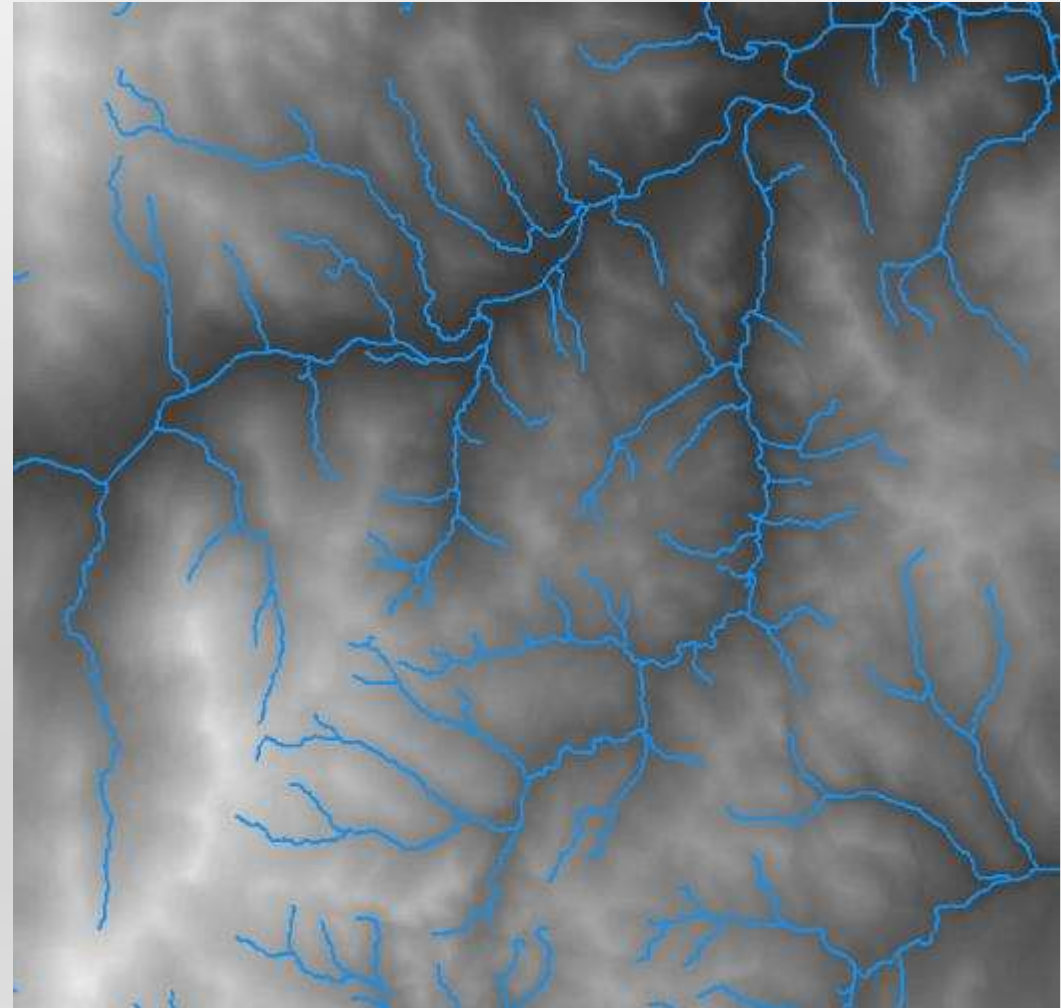
# DIGITAL ELEVATION MODELS

- Elevation models can be used to:
  - Determine how water will drain from the surface
  - Create contour lines for elevation
  - Determine watershed boundaries
  - Calculate area and volume
  - Calculate Slope
  - “Hillshade” model creation for viewing terrain



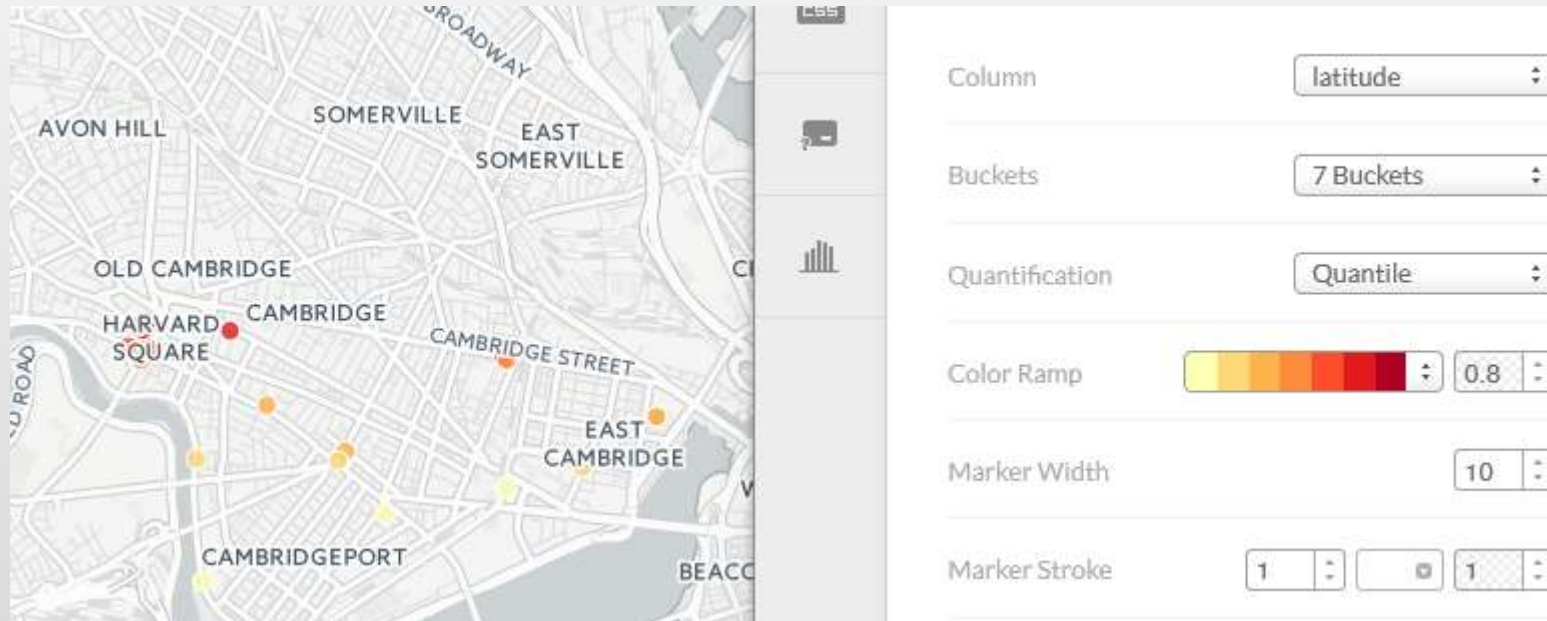
# ANALYZE RASTER DATA: SURFACES AND DIGITAL ELEVATION MODELS

- DEM's can also be used for cut/fill analysis, volume calculations, generation of hillshade models, slope models and aspect models



# WORKING WITH GIS

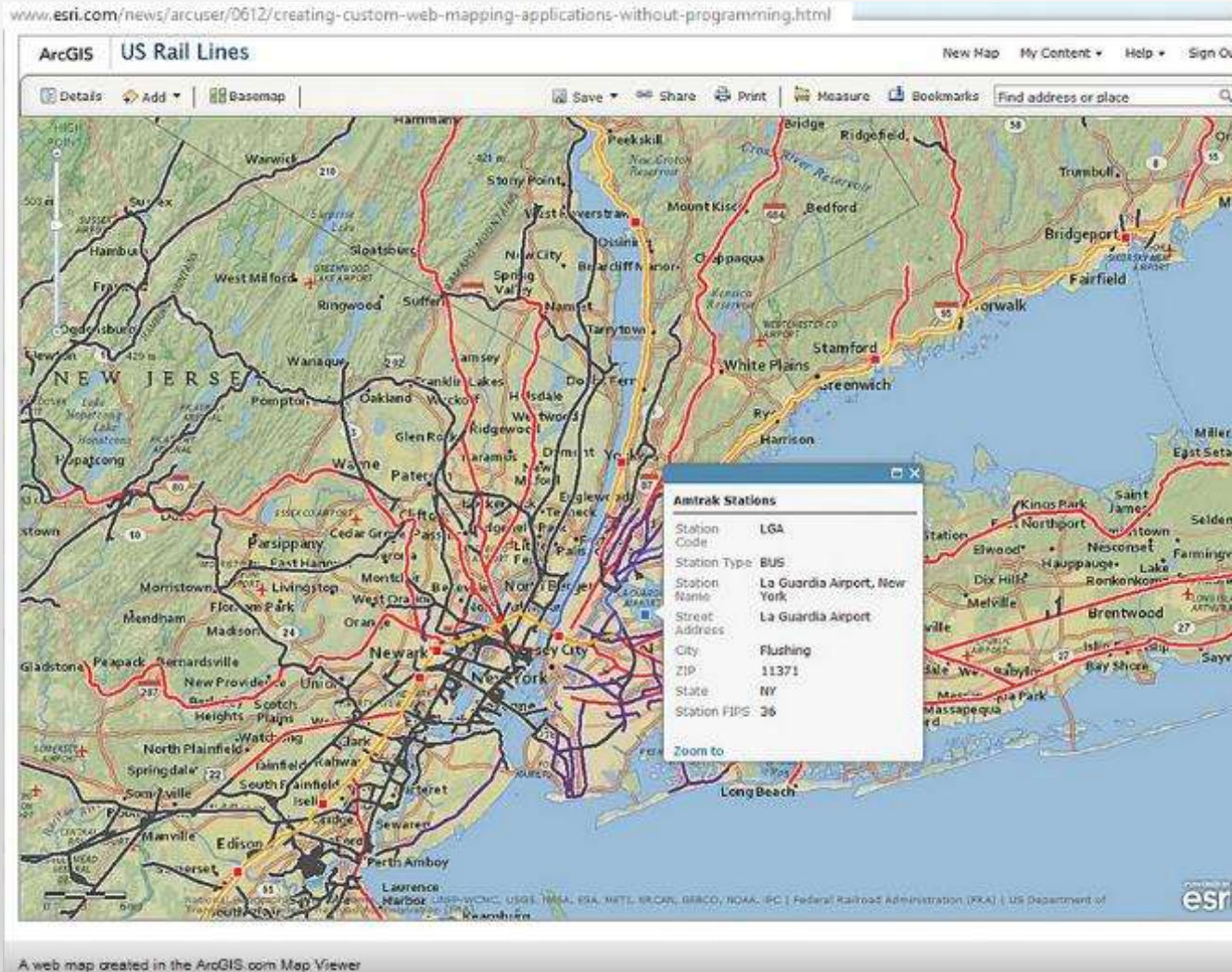
## CHOROPLETH SYMBOLOGY, BUBBLE MAPS



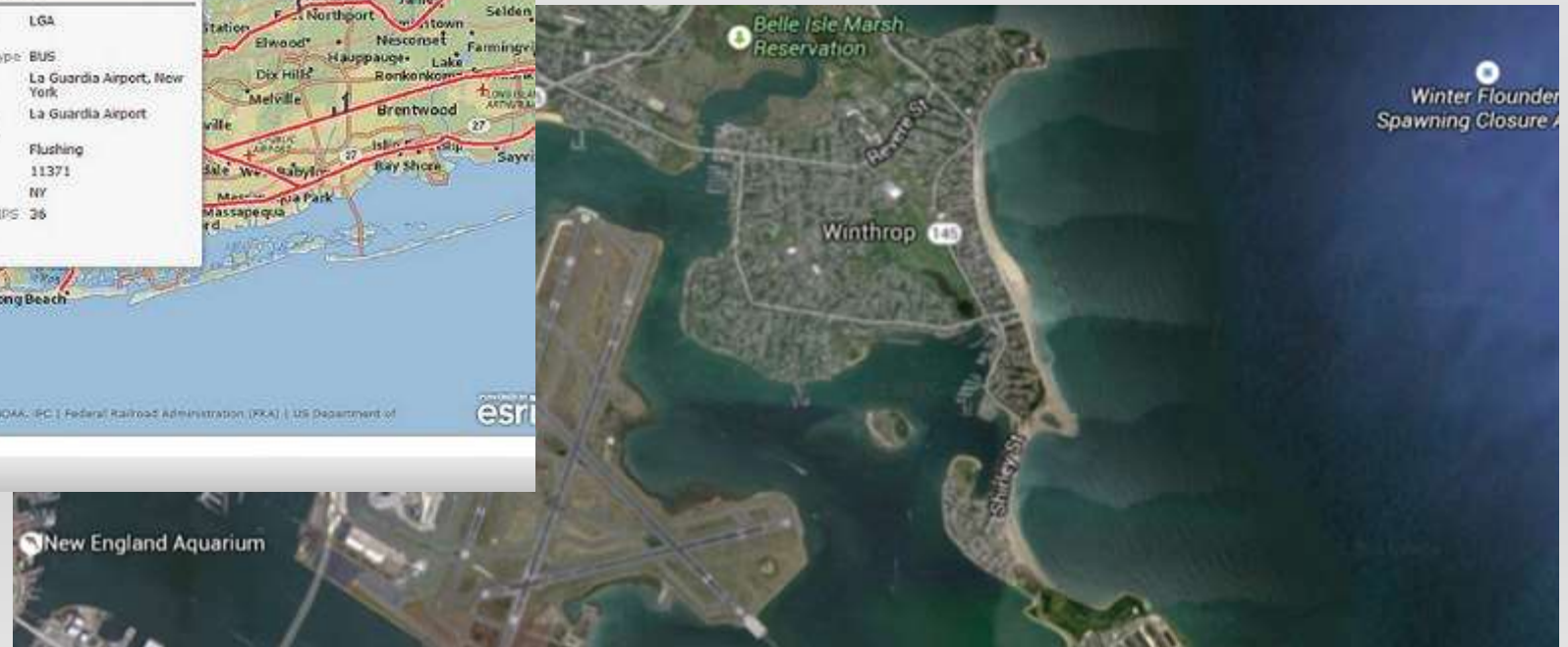
- In a choropleth map, areas or points are shaded or patterned in proportion to some numerical or statistical value such as population density or per-capita income
- In a bubble map, points or regions are sized proportionally according to a particular statistical value. Bubble maps are sometimes called intensity maps.



# WEB MAPPING



- Today, GIS can be done with desktop software, but also with web-based tools like ArcGIS Online and Google Maps “my maps” feature.



# WHERE CAN I FIND DATA?

- There are a wide variety of GIS data available from many sources
- Dartmouth Library Research Guide on GIS Data:
  - Located here: <http://researchguides.dartmouth.edu/gisdata>
- Federal Government:
  - Data.Gov: <http://www.data.gov/geospatial/>
  - National Map: [http://nationalmap.gov/small\\_scale/atlasftp.html](http://nationalmap.gov/small_scale/atlasftp.html)
- New Hampshire, Statewide GIS Clearinghouse:  
<http://www.granit.unh.edu/data/downloadfreedata/downloaddata.html>
- Vermont Center for Geographic Information: <http://vcgi.vermont.gov/>
- Other states – Most states now have a clearinghouse and office of Geographic Information
- Contact Research Computing: [research.computing@Dartmouth.edu](mailto:research.computing@Dartmouth.edu) or <http://rc.dartmouth.edu/>
- Create your own: GPS devices, professional survey data, digitizing (on-screen creation and editing of data)



# DATA SOURCES, FORMATS & METADATA

- Data, depending on its source and the methods used to collect and process, can vary widely.
  - GIS datasets are collected at varying scales and accuracies.
- “**Metadata**” is the term used for the file that should accompany the dataset. This file helps to explain what is in the dataset, who produced the dataset, and what its intended purpose was for producing the data
- Common Vector formats: geodatabase, shapefile, KML, KMZ, geojson, xyz, comma-separated (csv)
- Common Raster formats: JPG, TIFF, IMG, GRID

## DATA & METADATA

- One way to think about metadata, it is analogous to text that was often imbedded in old photographs
- The text was used to document where and when the photo was taken, and sometimes who took the photo



# METADATA

- Information that describes a dataset, including but not limited to how the data was collected, who collected it, when it was collected
- “Data about data”
- ALWAYS ask for Metadata, and read it to understand the dataset
- Metadata is often included with a downloaded dataset, but not always. Look for metadata in html, xml, txt or doc format.
- At times you may need to contact the data producer or data steward for metadata.

# SAMPLE METADATA FILE

- Metadata from the National Wetlands Inventory, a US Federal Government data layer published by the US Fish & wildlife Service, the USGS Geographic Names Inventory

The screenshot shows a web browser window with the URL `www.granit.unh.edu/data/metadata?file=nwi/nh/nwi.html`. The page features a navigation menu with links for Home, About Us, News, Projects, and Resource Library. Below the menu, there are links for Data 101, Download Free Data, Order Data, and Online Maps & Services. The main heading is "National Wetlands Inventory". A search box labeled "Search GRANIT" is present. On the left sidebar, there are links for "Search Database using Data Discovery Tool", "Layer List: Alphabetical Order", "Layer List: Data Category", "Max Parcel Information", and "GRANIT Data Questions?". At the bottom left, there is a "GIS Event Calendar" for August, showing a grid of dates from 1 to 8, with the 5th highlighted in red. The main content area contains the text "Metadata also available as - [Parseable text] - [SGML] - [XML]" and a section titled "Metadata:" with a list of links: Identification Information, Data Quality Information, Spatial Data Organization Information, Spatial Reference Information, Entity and Attribute Information, Distribution Information, and Metadata Reference Information. Below this list, there is a section titled "Identification\_Information:" with the following details: Citation: Citation\_Information: Originator: U.S. Fish & Wildlife Service, National Wetlands Inventory; Publication\_Date: 200502; Title: National Wetlands Inventory; Geospatial\_Data\_Presentation\_Form: vector digital data.

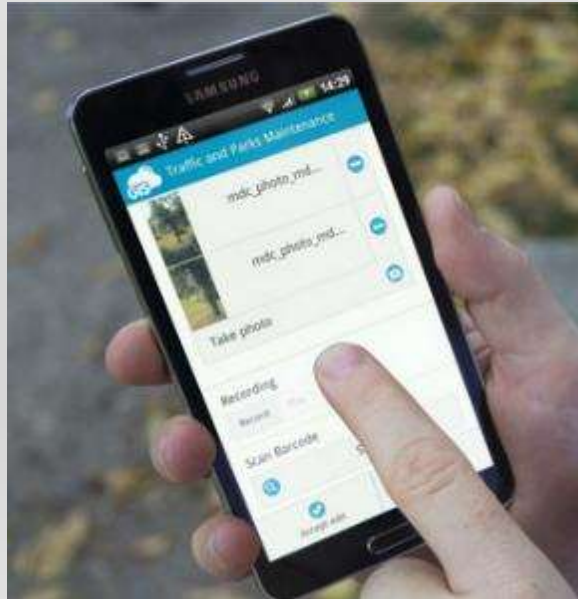
The screenshot shows a web browser window with the URL `geonames.usgs.gov/docs/metadata/gnis.txt`. The page displays the following metadata:

```
Identification_Information:
  Citation:
    Citation_Information:
      Originator: U.S. Geological Survey
      Publication_Date: 19810501
      Title: U.S. Geographic Names Information System (GNIS)
      Geospatial_Data_Presentation_Form: Live map layers in ESRI SDE; live
      tabular, geographic display and printable format; ASCII, UTF-8, or UTF-16
      Publication_Information:
        Publication_Place: Reston, VA
        Publisher: U.S. Geological Survey
        Online_Linkage: http://geonames.usgs.gov/
  Description:
    Abstract: The Geographic Names Information System (GNIS) actively see
    other interested organizations. The GNIS is the Federal standard for geog
    U.S. Board on Geographic Names, a Federal inter-agency body chartered by
    and to promulgate standard names to the public. The GNIS is the official
    geographic names use by all departments of the Federal Government; and th
    products of all types. See http://geonames.usgs.gov for additional inform
    Purpose: The Geographic Names Information System contains information
    States, associated areas, and Antarctica, current and historical, but not
    name of each feature and defines the feature location by state, county, U
    names or spellings other than the official name, feature designations, fe
    categories the geometric boundaries. The database assigns a unique, perma
    accessing, integrating, or reconciling feature data from multiple data se
    Federal, State, and local government agencies and other authorized contri
    public, as well as to numerous applications through a web query site, web
    request.
    Supplemental_Information: The U.S. Board on Geographic Names was crea
    establish and maintain uniform geographic name usage throughout the Feder
    the central authority to which name inquiries, name issues, and new name
    agencies associated with land management and cartography. Sharing its res
    principles, policies, and procedures governing the use of both domestic a
    Time_Period_of_Content:
      Time_Period_Information:
        Range_of_Dates/Times:
          Beginning_Date: 1974
          Ending_Date: Present
      Currentness_Reference: Ground Condition
    Status:
      Progress: In work
```



# CAPTURING GEOGRAPHIC DATA IN THE FIELD

- Professional Survey GPS
- Recreational mapping GPS units
- Laptops or Tablets with GPS card or antenna
- Smart phones with location services such as GPS chip or cell-phone tower triangulation
- Drones equipped with cameras capable of producing stereo-pair orthoimagery of the terrain

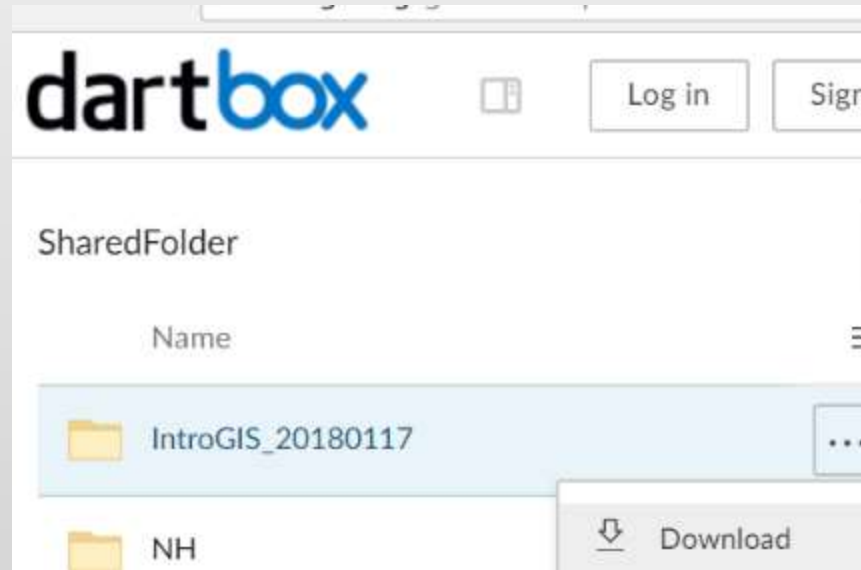




# HANDS-ON GIS EXERCISE DATA

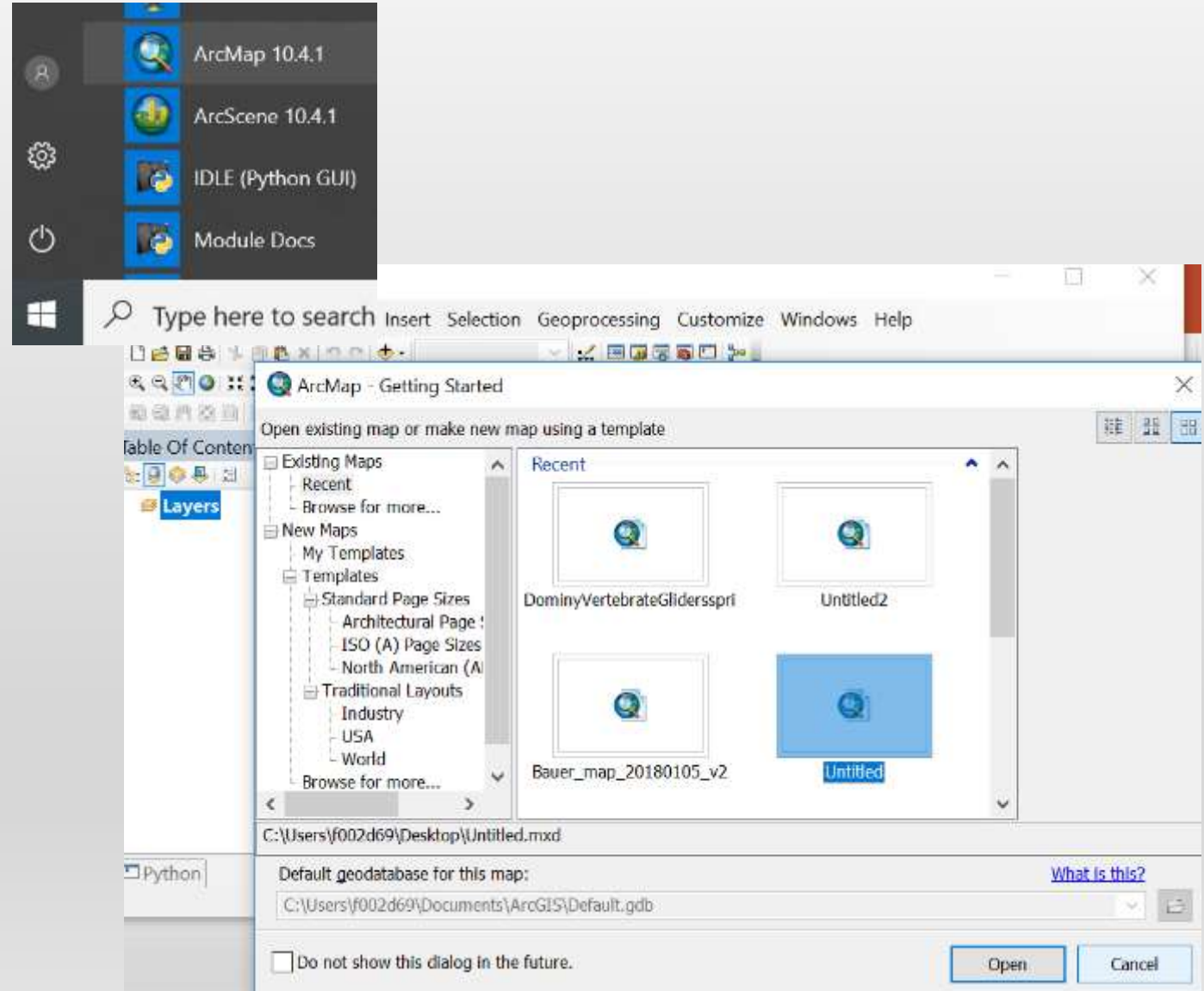
- Open a browser, navigate to

[www.dartgo.org/gisworkshop](http://www.dartgo.org/gisworkshop)



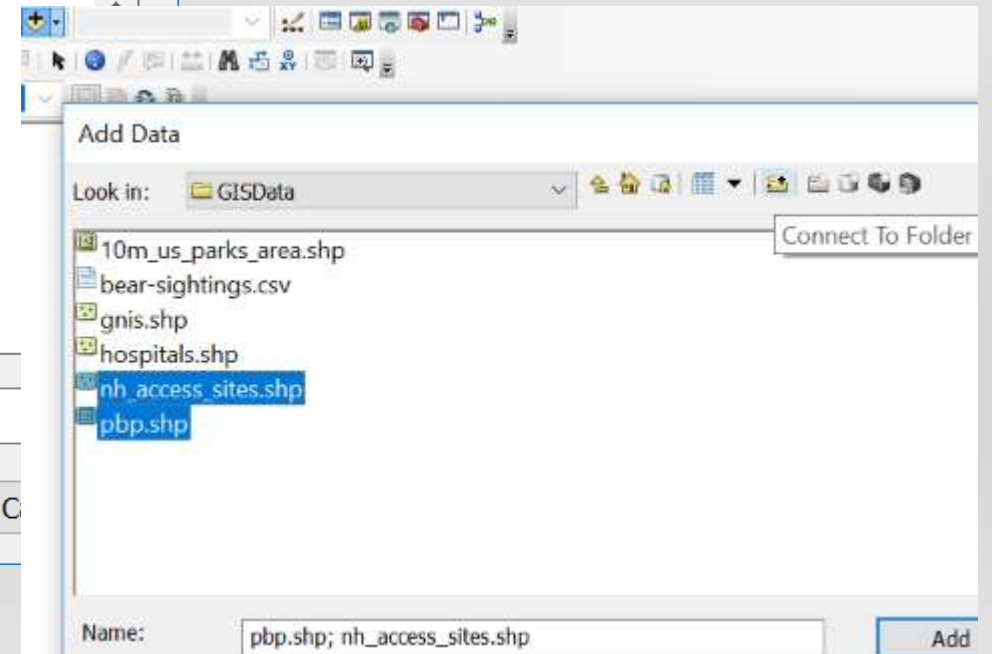
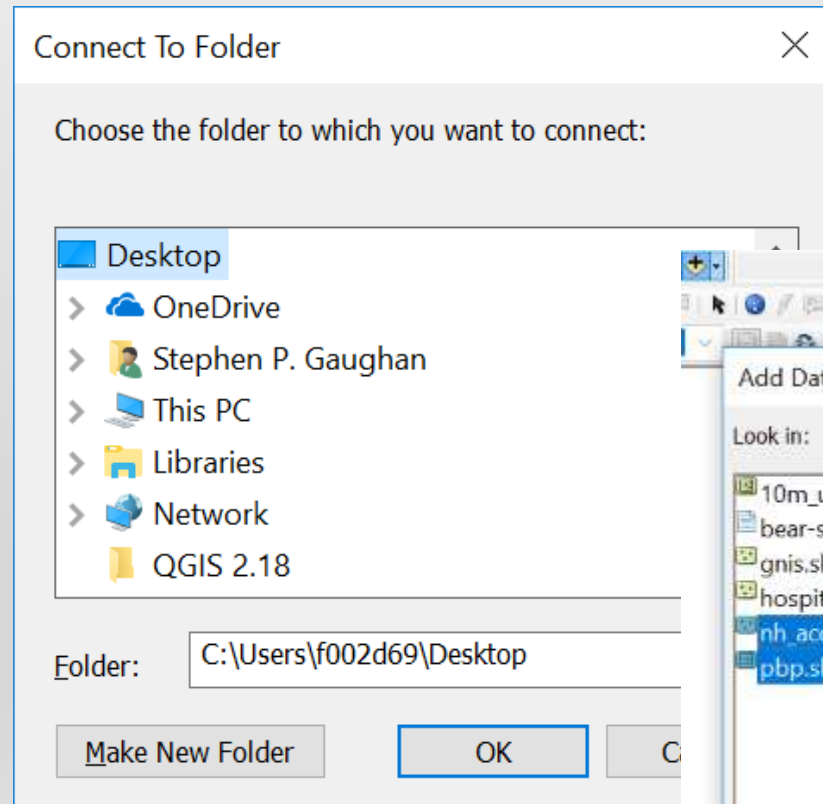
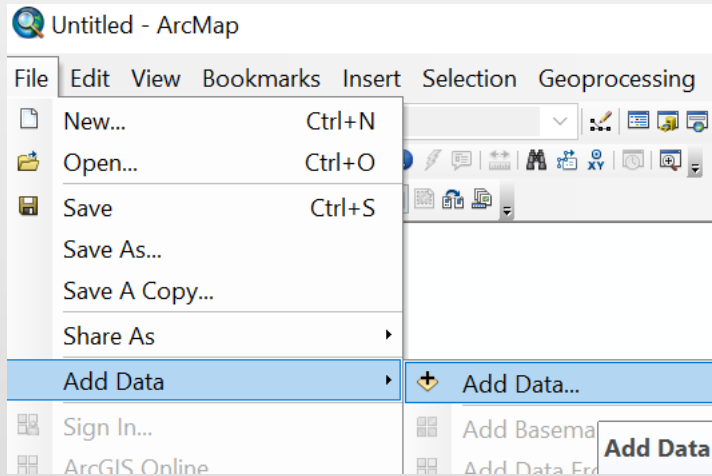
# READY TO MAKE A MAP?

- Pan, Zoom, Search, Identify, layer transparency
- Add base map, add data
- Select, filter
- Open ArcMap, open a new, blank map



# ADDING DATA

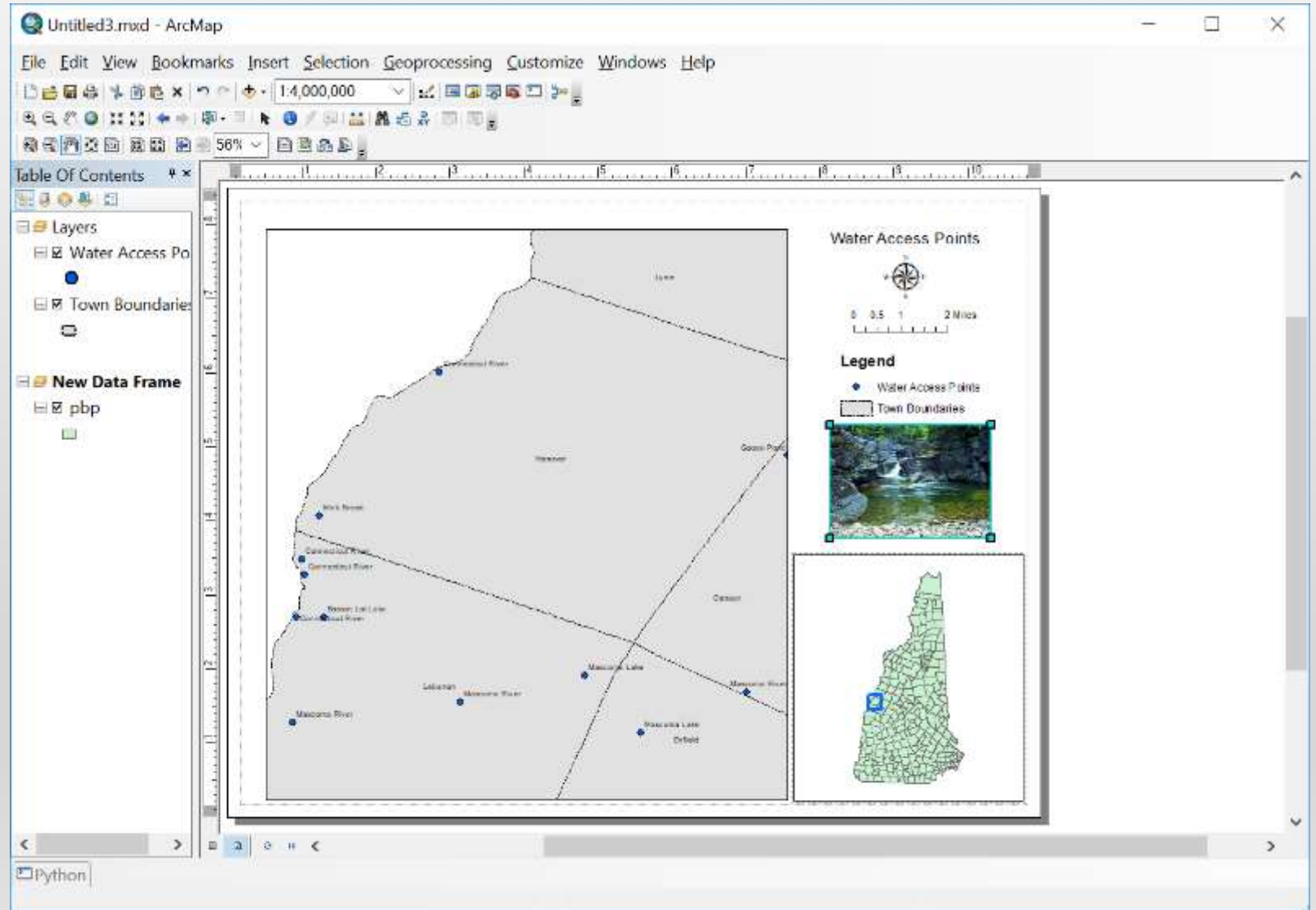
- Add data from local drive, or from the web



# PUBLISHING MAPS – LAYOUT VIEW

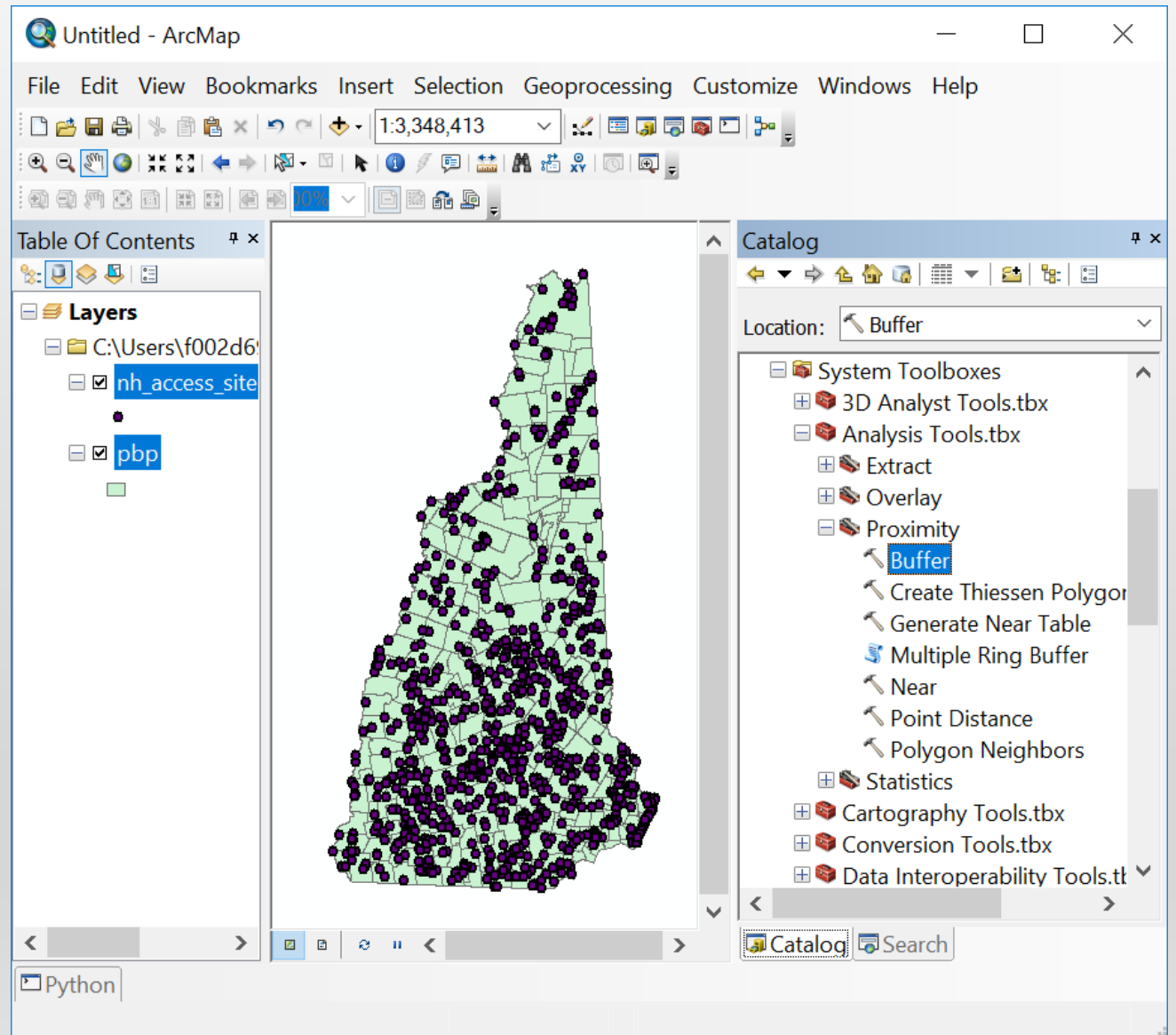
Make a map to add to a publication or poster, export to PDF, JPG or to send to a printer or plotter

- Map title
- North arrow or compass rose
- Scale bar
- Legend
- Sources of data (abbreviated metadata)
- Reference map
- Date of publication, author(s)
- Funding Info & disclaimers (for planning purposes only, not intended for legal boundary use...)



# SPATIAL ANALYSIS

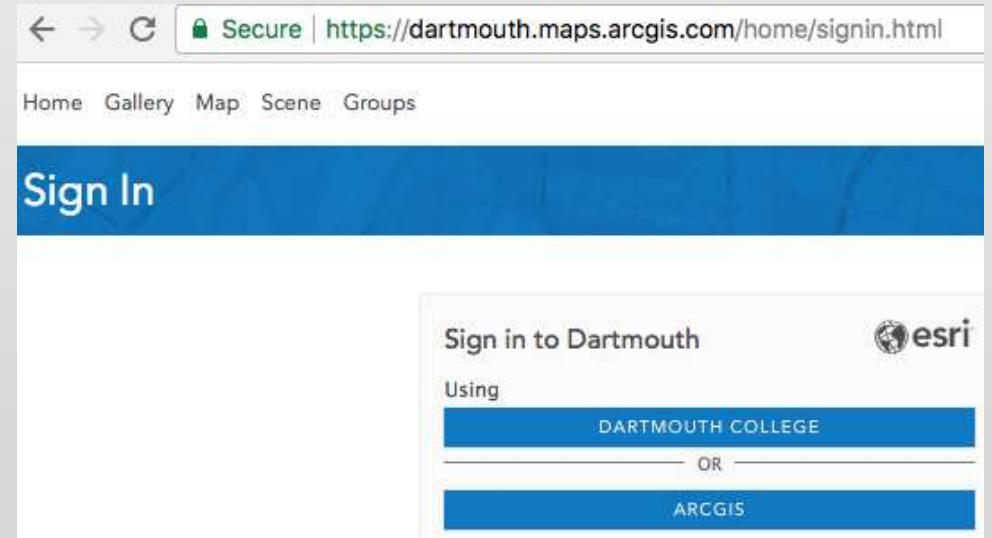
- Using “ArcToolbox”





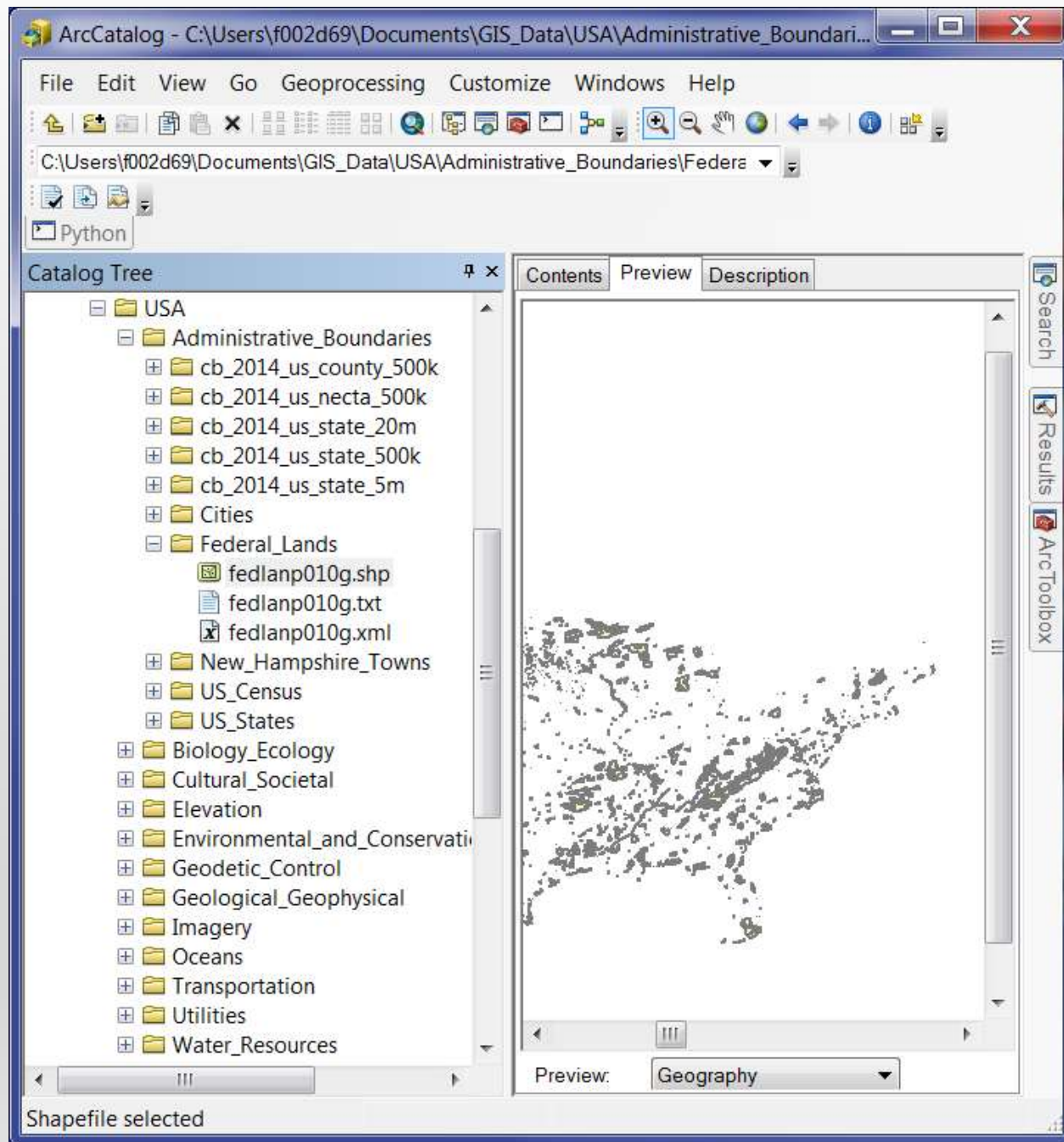
# “ARCGIS ONLINE” LIGHTWEIGHT GIS

- Navigate to <https://dartmouth.maps.arcgis.com/home/signin.html>
- Sign in on the ArcGIS sign-in page, click to “Sign in with Enterprise Login”
- Click the “Dartmouth College” button
- Once logged in, click “Content” and then “Add Item” or “Create”
- Access Tutorial at <https://learn.arcgis.com/en/projects/get-started-with-arcgis-online/>



# ARCGIS DESKTOP – ARCCATALOG

- Preview GIS data layers in ArcCatalog
- Read Metadata
- Manage data layers
- Use ArcToolbox tools
- Write metadata



QUESTIONS?

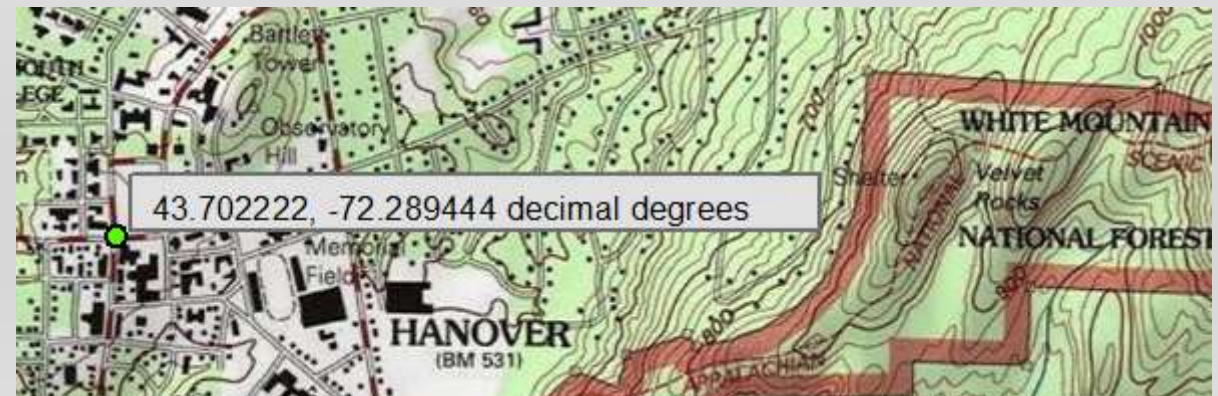


# SUPPLEMENTAL INFORMATION



# CREATING GIS DATA

- GIS Data can be generated by a “geocode” process.
- For instance, 2 East Wheelock Street, Hanover, NH can also be described by its WGS84 Latitude and Longitude coordinates, and then placed in a GIS with other base layers



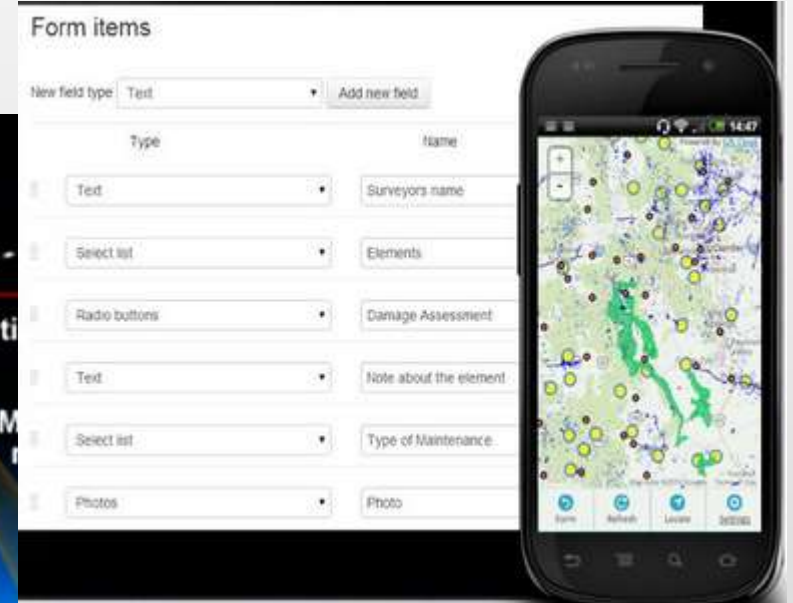
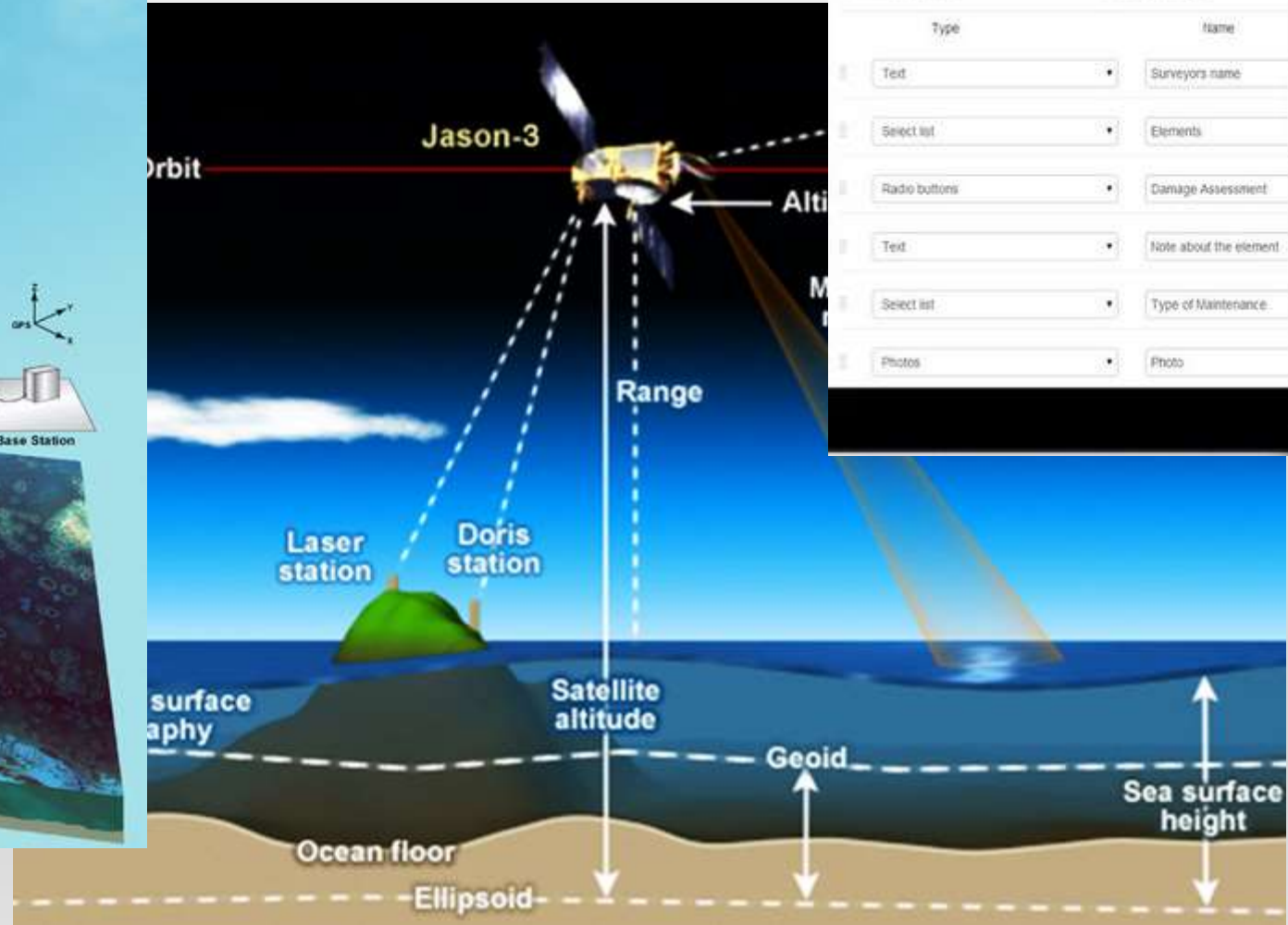
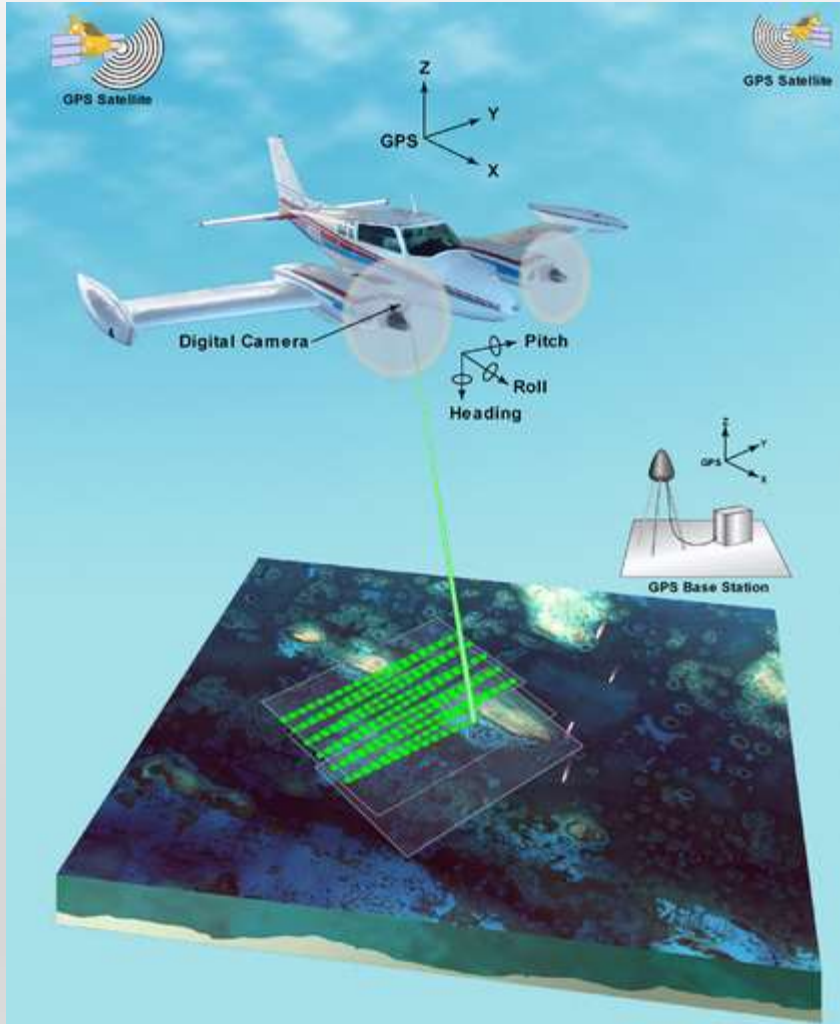
## SCAN AND GEOREFERENCE OLD MAPS, AERIAL PHOTOS

- Have an old map or image? They can be scanned and brought in to approximate alignment with other GIS data layers through the process of “georeferencing”



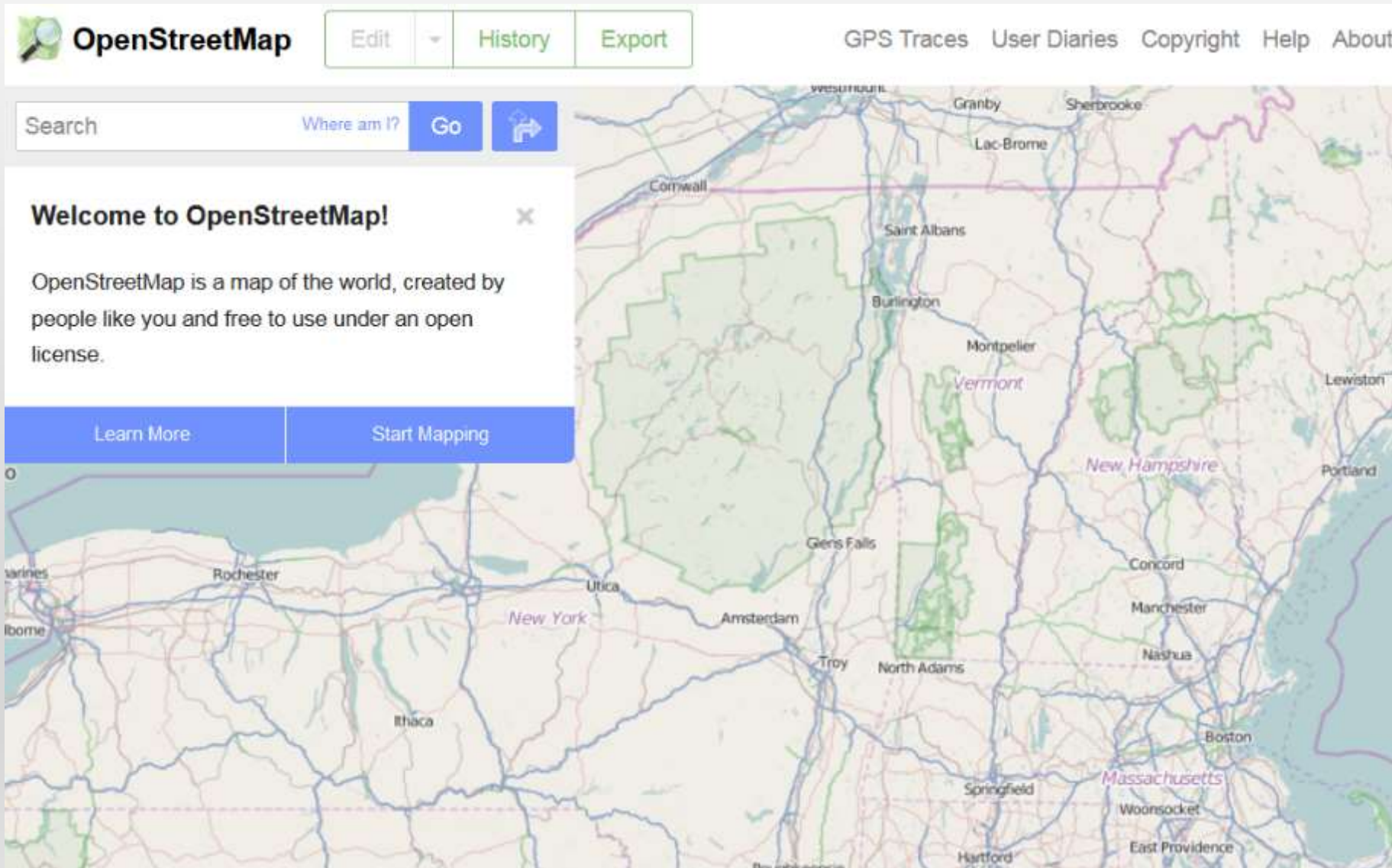


# CREATION OF GIS DATA



# OPEN STREET MAP DATA

[www.openstreetmap.org](http://www.openstreetmap.org)



- Open Street Map has open data for you to view, download and use
- Data can also be openly contributed to Open Street Map



# DATA FORMATS AND SOFTWARE

## DATA

- ArcGIS
  - Geodatabase
  - Shapefile
  - JPG, TIFF
  - KML/KMZ
- Google Earth
  - KML/KMZ
- Google Earth Pro
  - Shapefile

## Open-Source Software

- QGIS
- GRASS GIS
- MapWindow
- gvSIG
- R

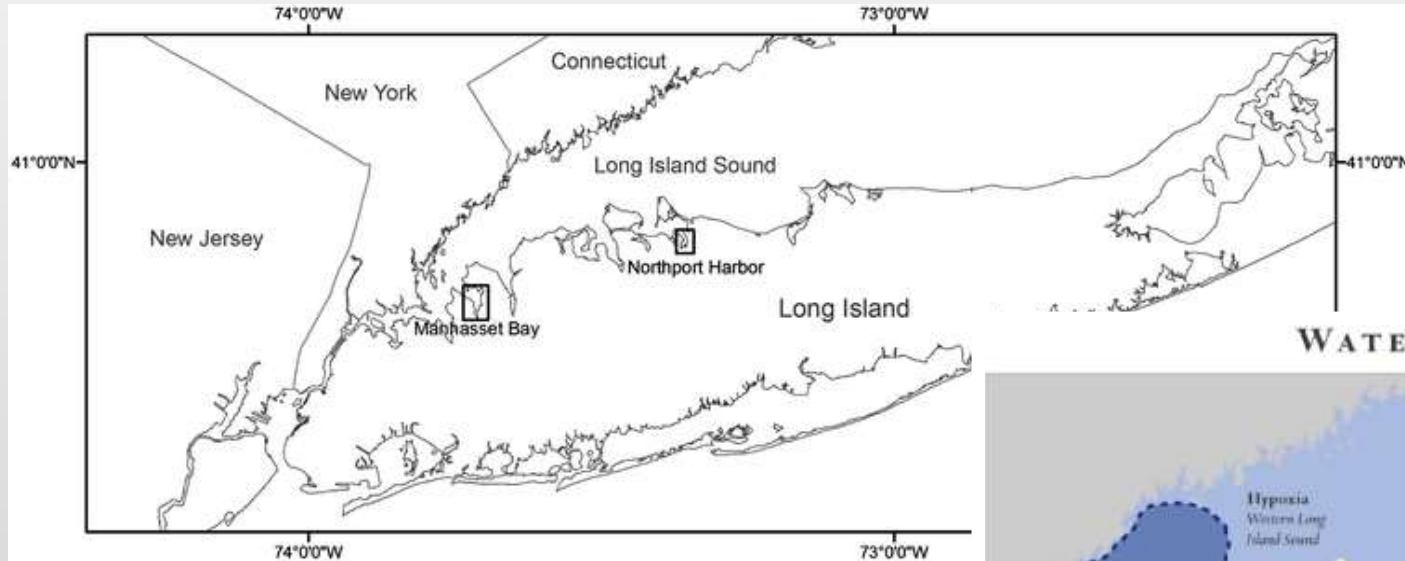
## Proprietary Software

- ESRI ArcGIS Desktop
- Google Earth Pro
- ERDAS Imagine
- IDRISI
- ENVI

# DATA MANAGEMENT TIPS AND TECHNIQUES

- GIS datasets can be very large in size
- A single dataset can at times be comprised of many files on your computer's file system
- Structure your project data in a way that makes sense to you. Use file names that make sense, and fill out metadata descriptions for files you generate and plan to keep. Keep detailed notes about data sources and data storage
- Take notes on your processing steps
- Back up data that can't be recreated easily, storing a copy on a server or external drive, keeping careful track of the “authoritative” copy of the data.

# MAPS FOR JOURNAL PUBLICATIONS

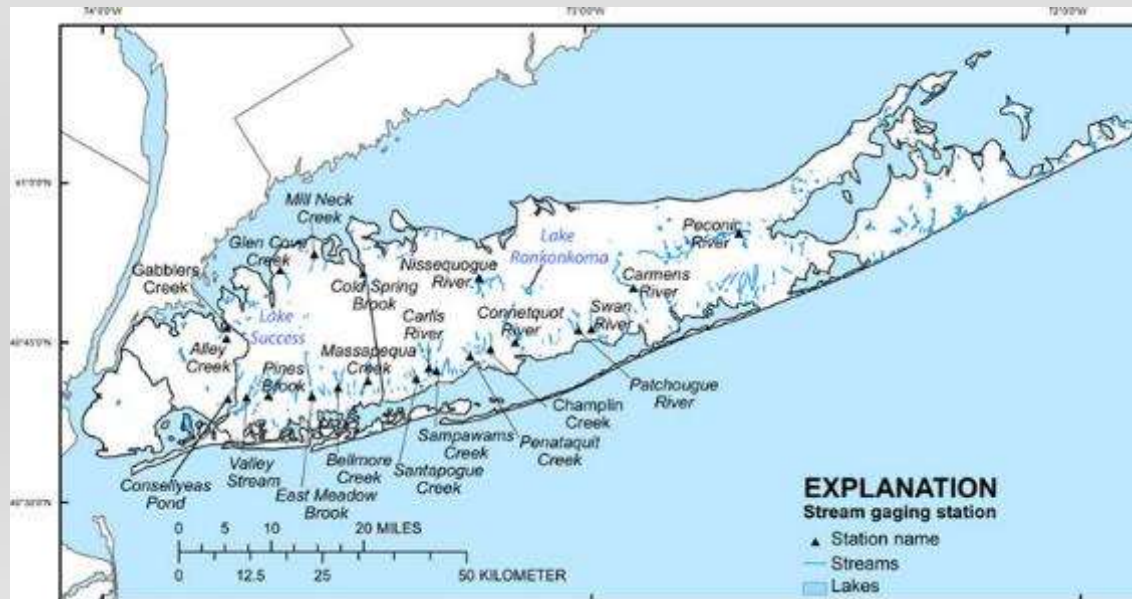


WATER QUALITY ISSUES, SUMMER 2013



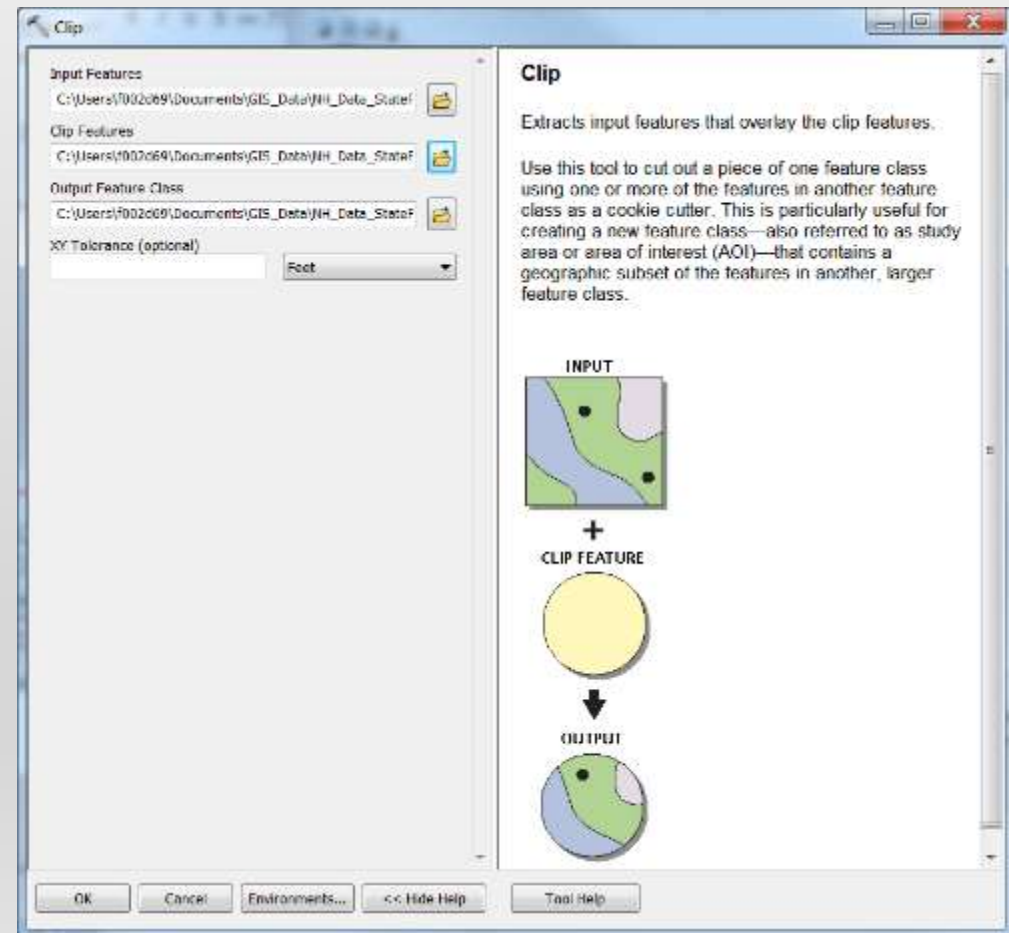
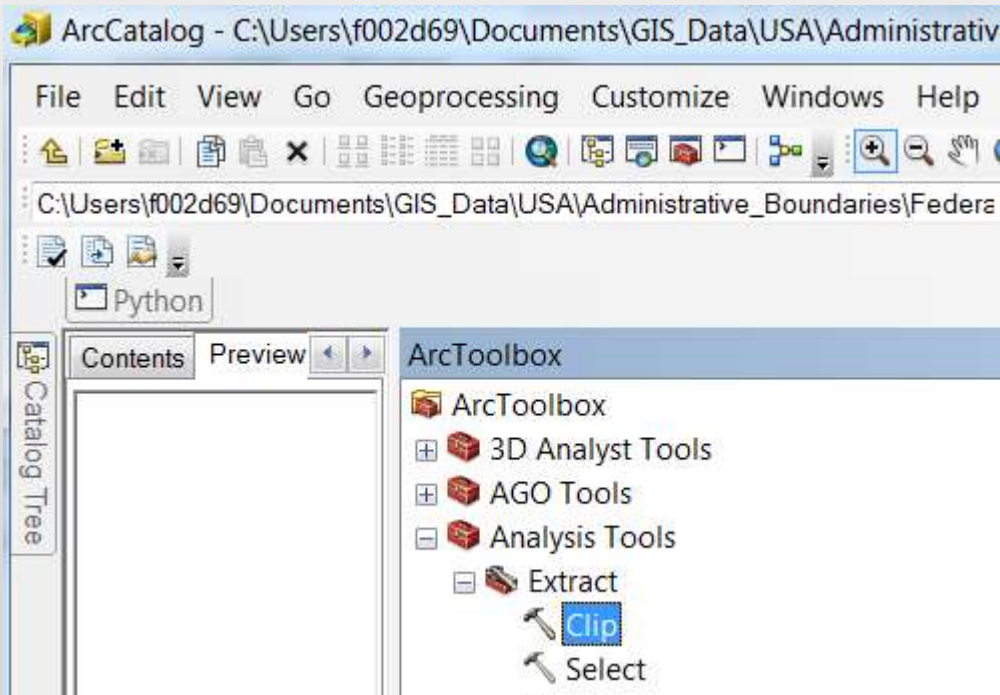
# COMMON MAP ELEMENTS

- Date of map production
- Author of map
- Inset locational map
- Compass Rose or North Arrow
- Scale bar
- Legend / Key
- Title
- Data Sources



# GIS ANALYSIS IN ARCGIS DESKTOP – ARCTOOLBOX, MODELBUILDER, PYTHON SCRIPTING

- Analysis can be done interactively or through scripting with Python. Multi-step models can be built with Python or Modelbuilder





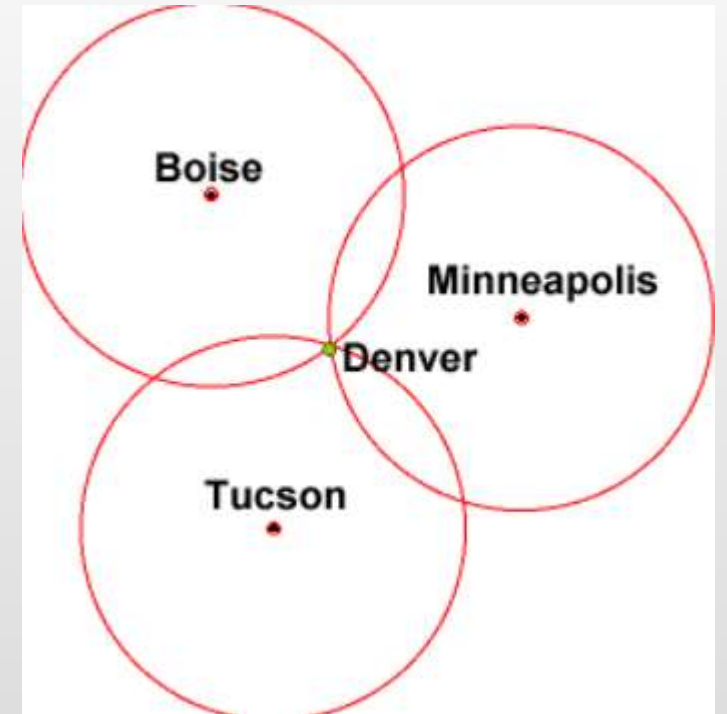
# GPS

- The project scope of work should drive the type of device required
- For 2-5 meter accuracy, a \$100 GPS device might do the trick if used properly
- For high accuracy applications such as surveying and construction, device kits can run over \$10,000 and require specialized training to use the devices properly.
- GPS units require the acquisition of signals from at least four GPS satellites, that must be widely distributed in the sky, in order for your device to estimate your position using trilateration
- Allowing the unit to remain in one location for a longer period of time may improve the trilateration process



# GPS

- On the ground, if we knew that we were a certain distance from Boise, ID, Minneapolis, MN and Tucson, AZ we could determine that we are near Denver, CO.
- With GPS, by knowing the time stamp sent by at least three satellites, we can use  $\text{Distance} = \text{Rate} \times \text{Time}$ .
- Rate is the speed of light, the speed of the radio transmission



# GIS COLLECTOR APPS FOR MOBILE

- Recently, a variety of GIS data collection tools have been developed for mobile devices such as phones and tablets
- These use the mobile device's GPS chip and tower-signal proximity for location
  - Collector For ArcGIS
  - GIS Cloud MDC (mobile data collector)
  - QGIS for Android
- Often difficult to know, record or assess positional accuracy metrics such as PDOP
- Examples include Collector for ArcGIS, Mobile Data Collector-MDC GIS Cloud, ArcGIS Survey 123

