

Introduction to GIS

<http://libguides.mit.edu/gis>



Overview

- What is GIS?
- Types of Data and Projections
- What can I do with GIS?
- Data Sources and Formats
- Software
- Data Management Tips



What is GIS?



Characteristics of GIS

The data

- Spatial
- Tabular

Methods

- Data input
- Data management
- Data analysis: answer questions that may not be explicitly stated in the data
- Data output: maps, new data

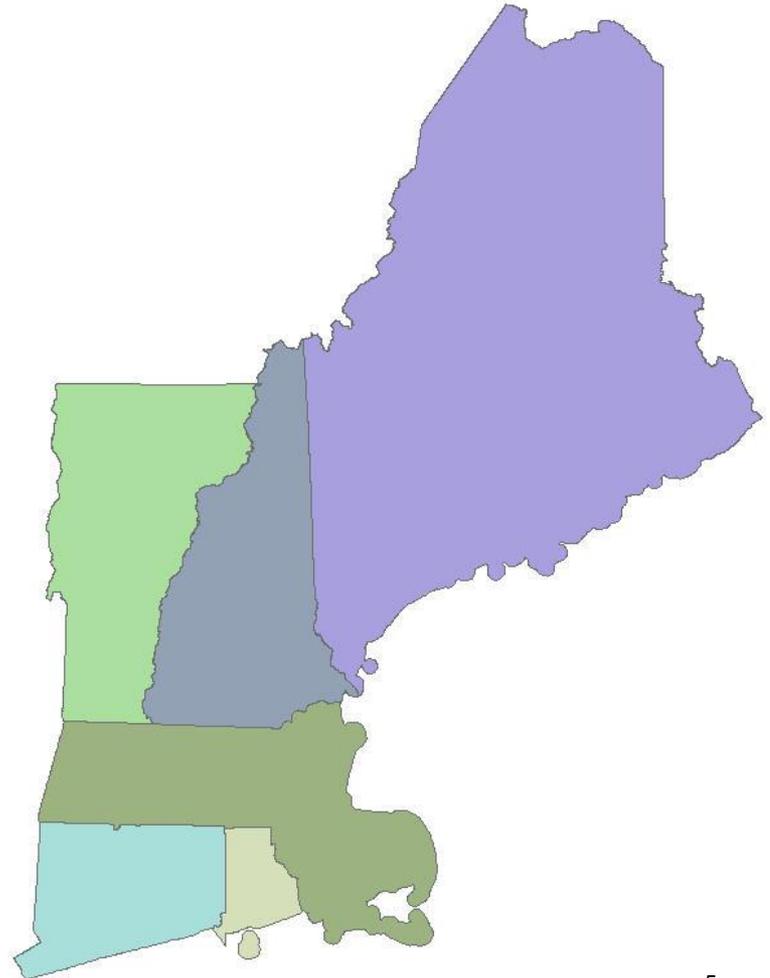
Software and hardware



Characteristics of GIS: Data Layers

With GIS software, you can digitally represent geographic objects with a variety of shapes and layer those shapes on top of one another to create maps and perform analysis.

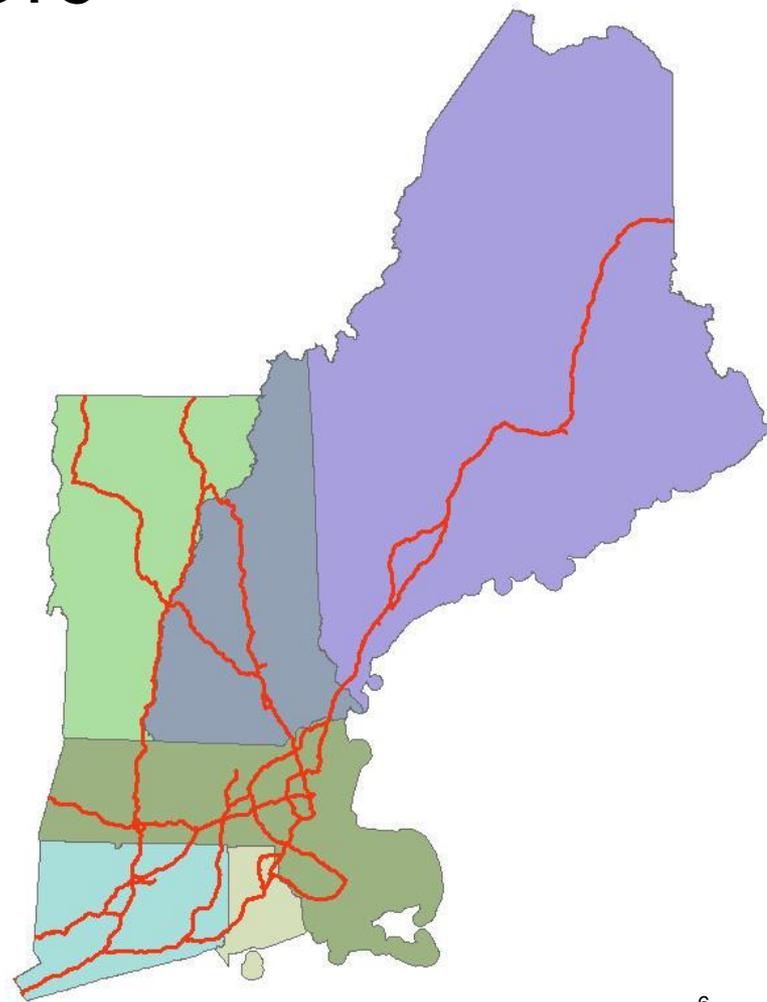
- Polygons



Characteristics of GIS: Data Layers

With GIS software, you can digitally represent geographic objects with a variety of shapes and layer those shapes on top of one another to create maps and perform analysis.

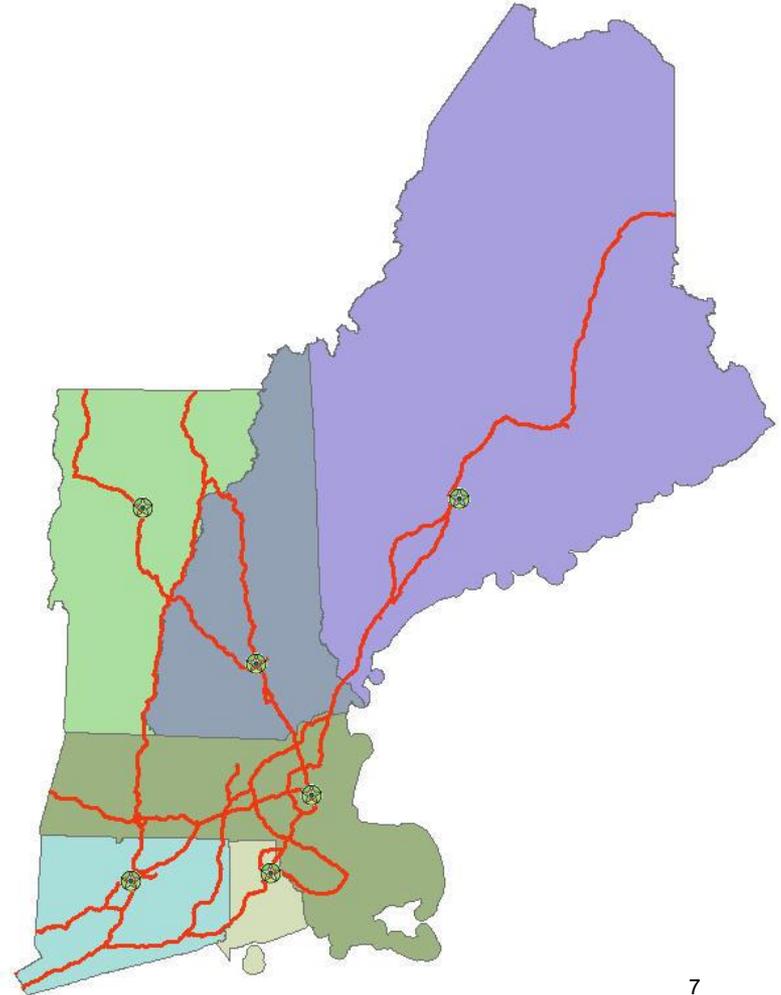
- Polygons
- Lines



Characteristics of GIS: Data Layers

With GIS software, you can digitally represent geographic objects with a variety of shapes and layer those shapes on top of one another to create maps and perform analysis.

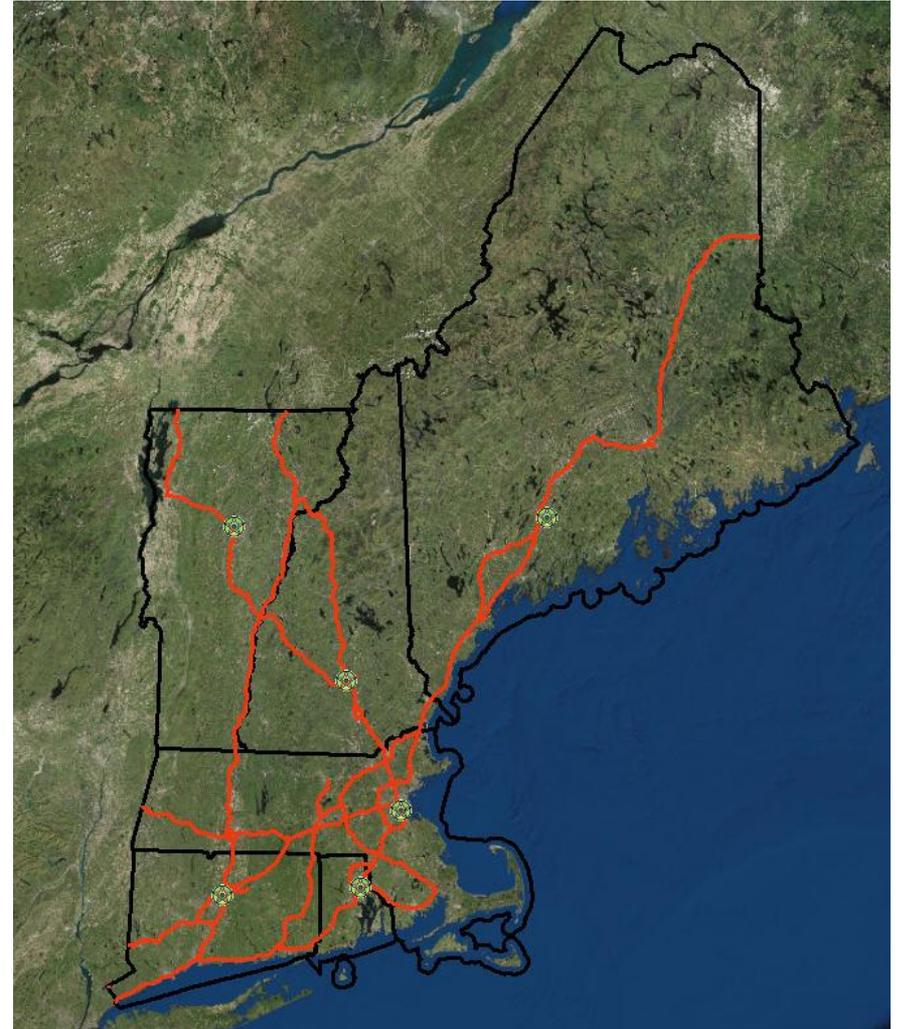
- Polygons
- Lines
- Points



Characteristics of GIS: Data Layers

With GIS software, you can digitally represent geographic objects with a variety of shapes and layer those shapes on top of one another to create maps and perform analysis.

- Polygons
- Lines
- Points
- Raster images (pixels)



Data Types: Spatial

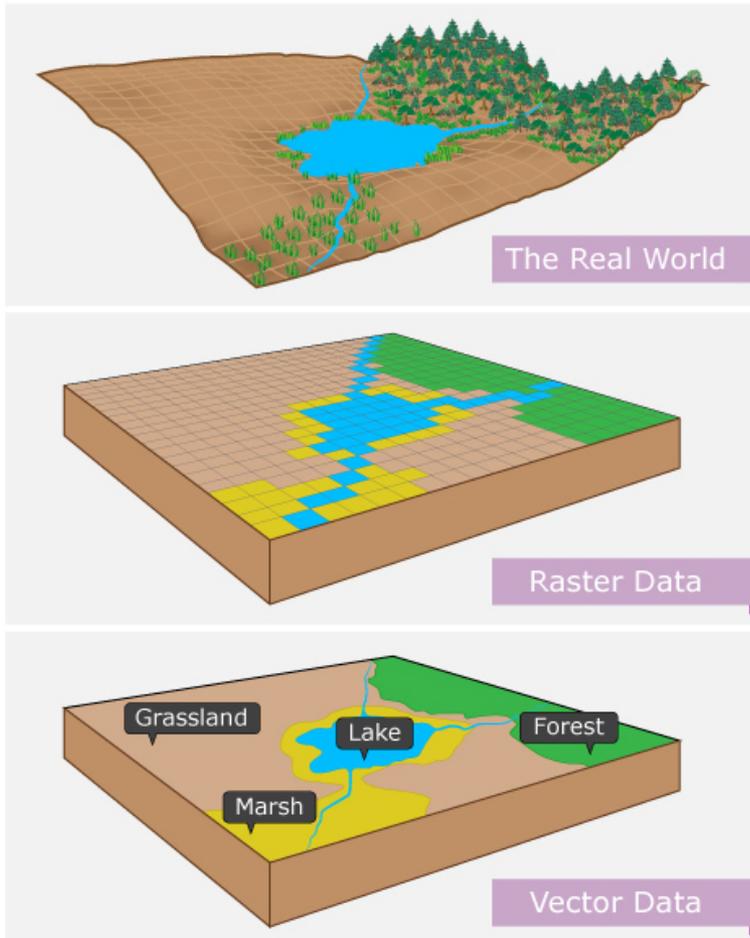


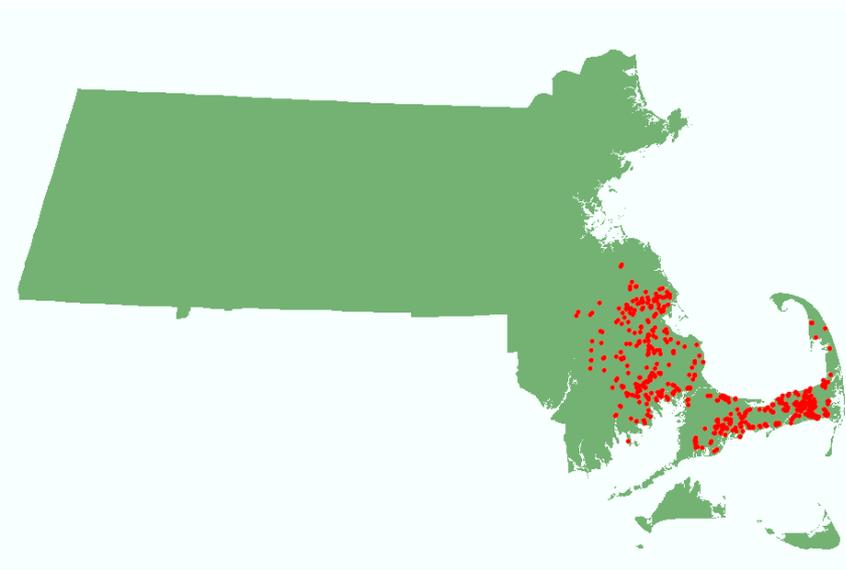
Image by MIT OpenCourseWare.

Spatial or coordinate data represent features that have a known location on the earth.

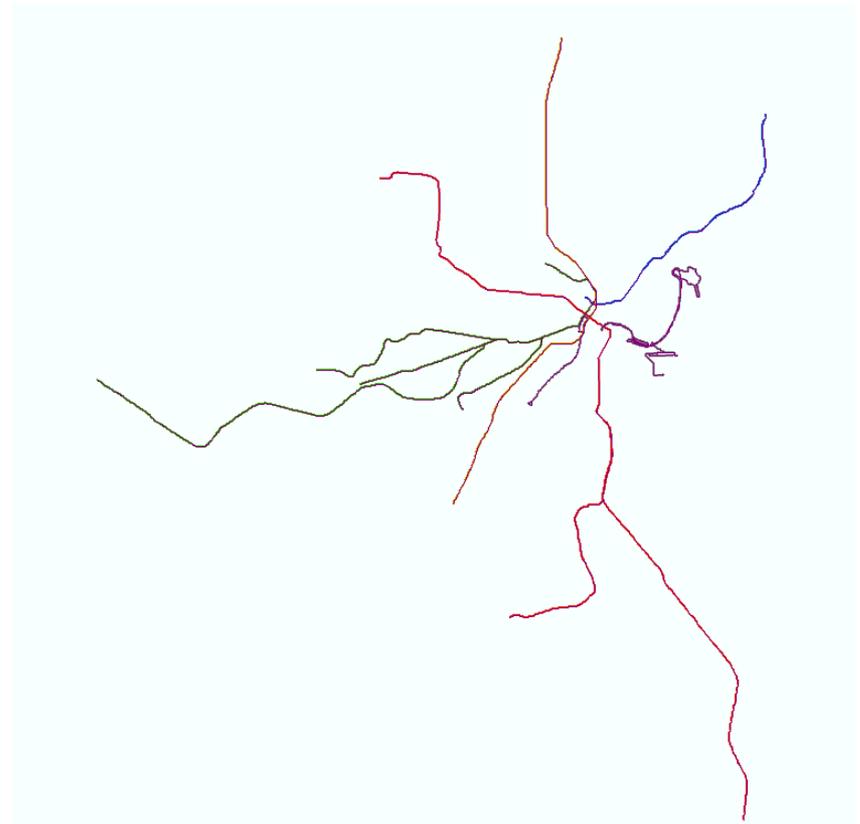
- **Vector:** Points, lines, and polygons
- **Raster:** Row and column matrix

Data Types: Vector

Polygon and Points



Lines



Data Types: Raster

A model of the world as a surface that is divided into a regular grid of cells, arranged into rows and columns.

- All cells (or pixels) must be the same size.
- All cells have a value.

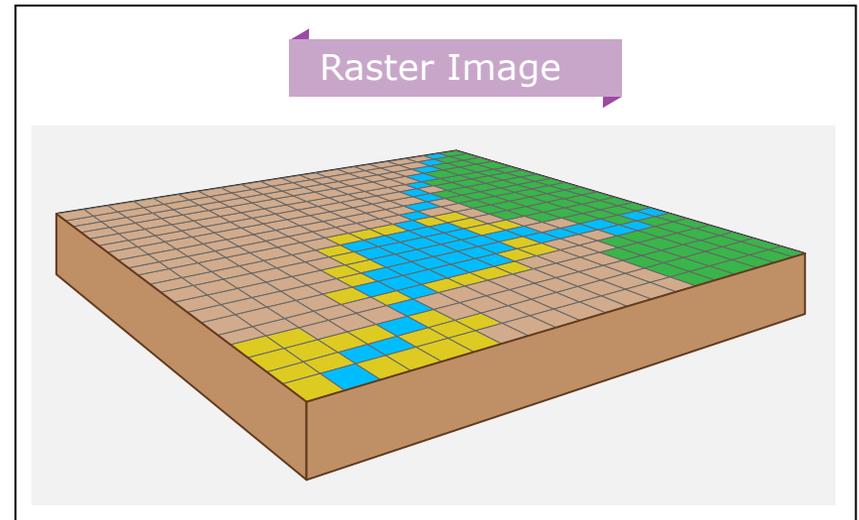


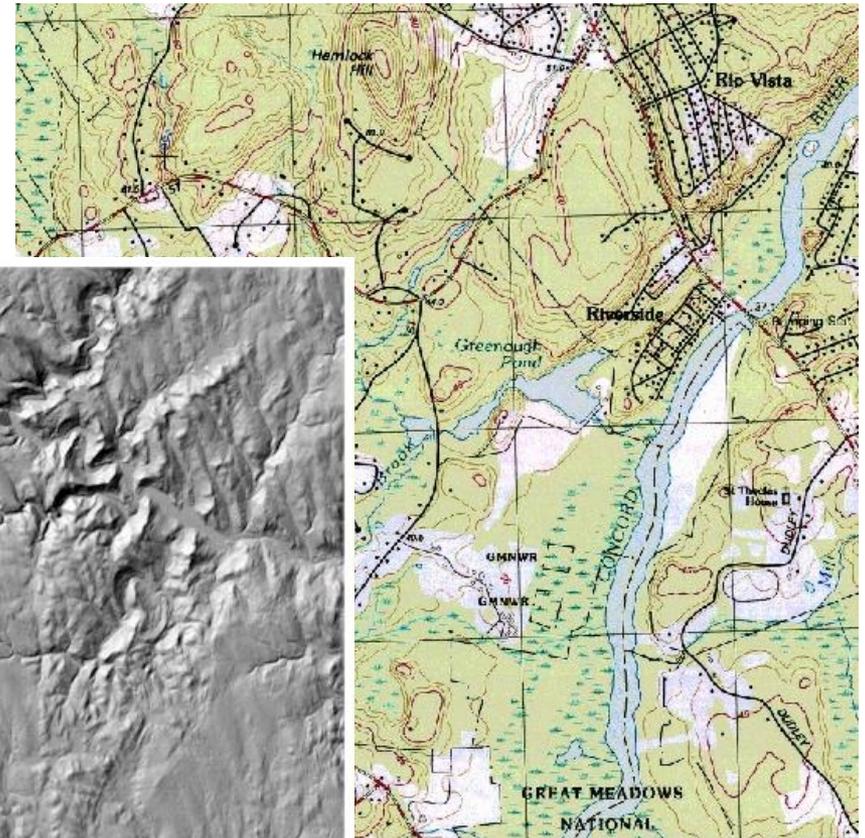
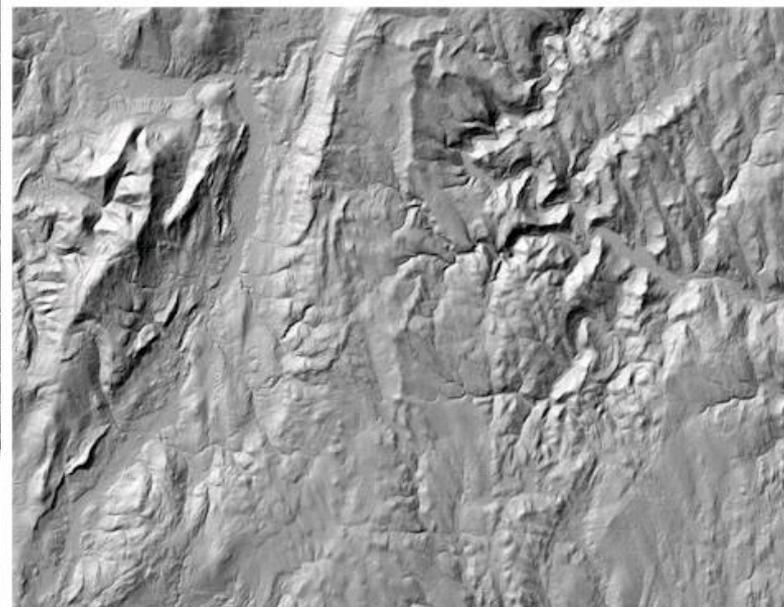
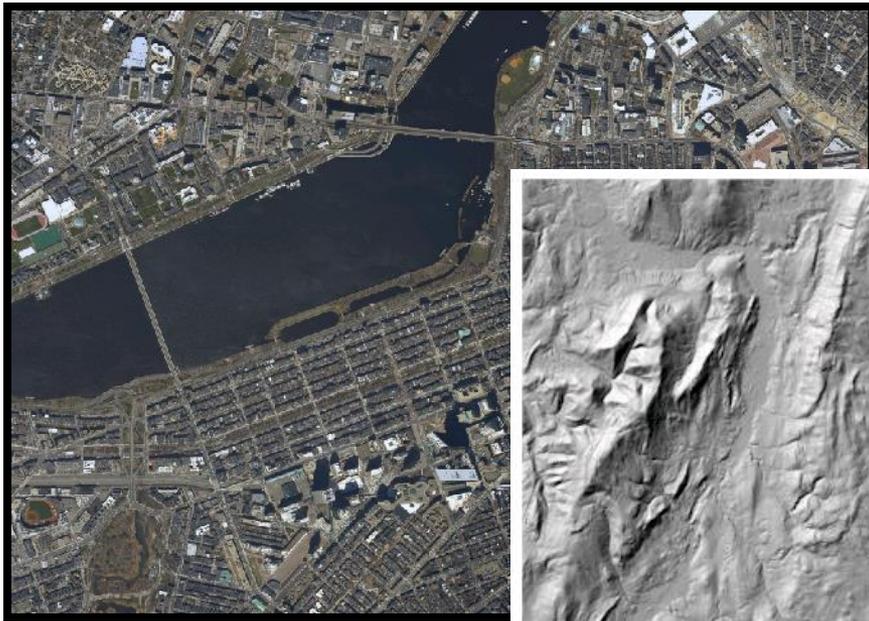
Image by MIT OpenCourseWare.

Image from: <http://resources.arcgis.com/en/help/main/10.2/index.html#//009t00000002000000>



Data Types: Raster

Rasters include images, elevation models, and scanned maps.



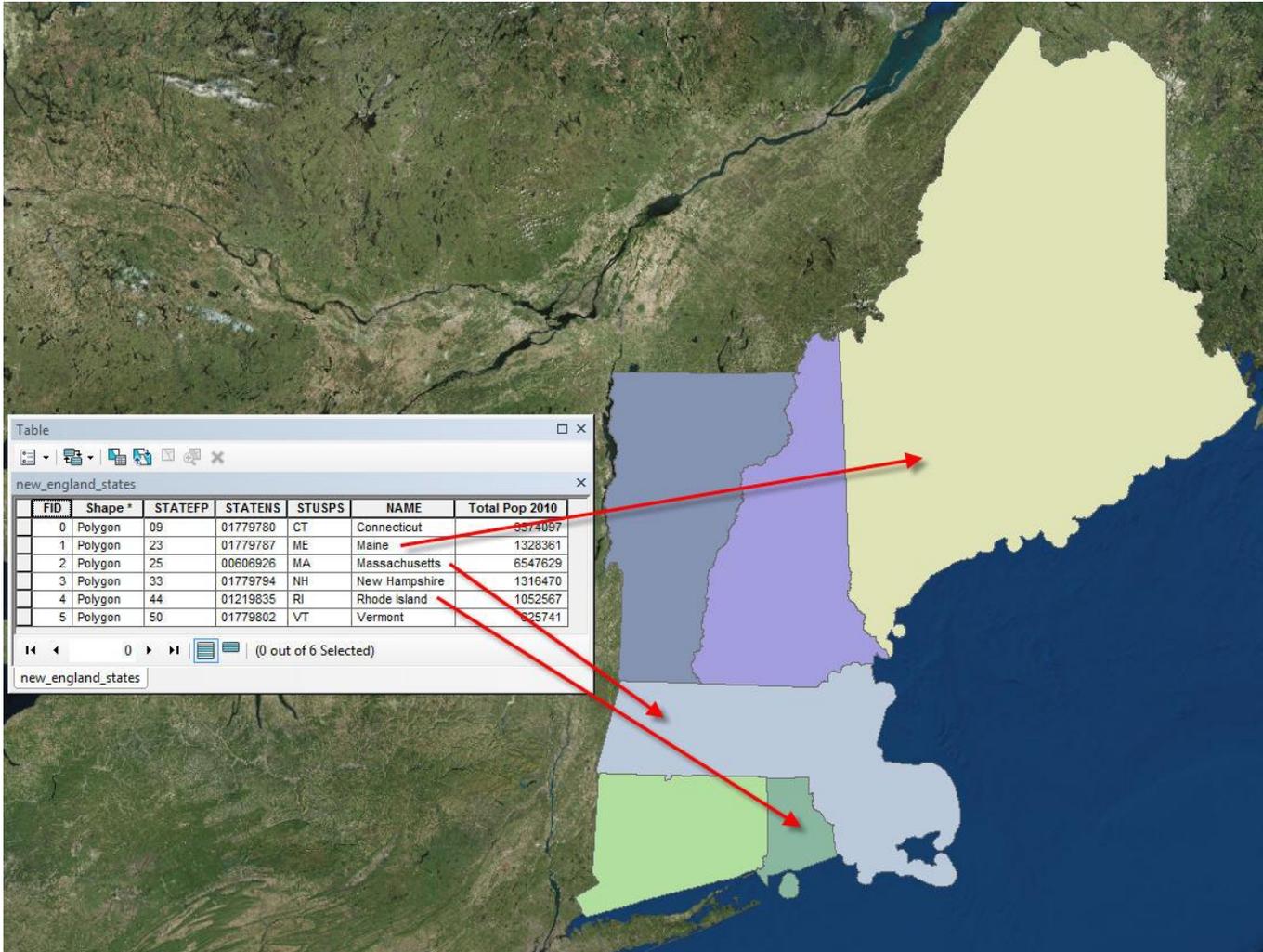
Data Attribute Table

- Spatial data have a backend database called an attribute table.
- It can be used for querying and analysis.
- All attributes can be mapped.

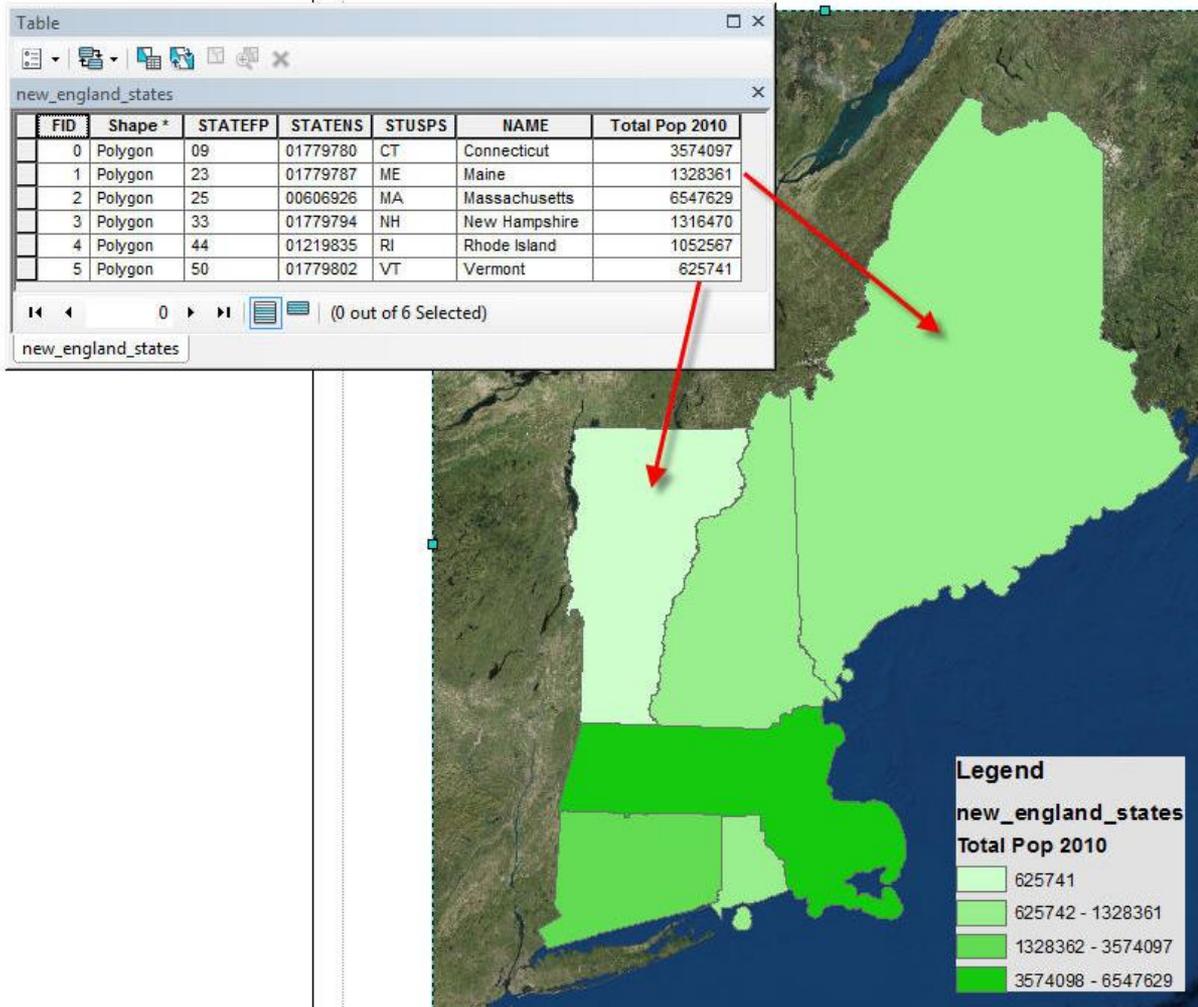


Data Attribute Table

Each state is represented with a different color.



Data Attribute Table



Each state is color coded based on its population.

Data Types: Tabular

- Table (CSV, Excel) or database (Access, Oracle, PostgreSQL)
- Can be transformed into spatial data and mapped:
 - Join with spatial data files by a common attribute (state name, unique ID, etc.)
 - Map as points using coordinates such as longitude and latitude gathered from a GPS device
 - Geocode: associate address fields with a street network



Map Projections

There are many different map projections. All map projections distort at least some of the following:

- Shape
- Area
- Distance
- Direction



What can I do with GIS?



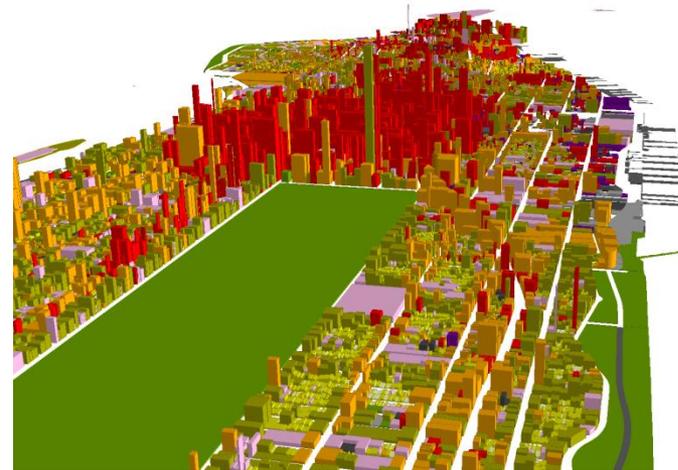
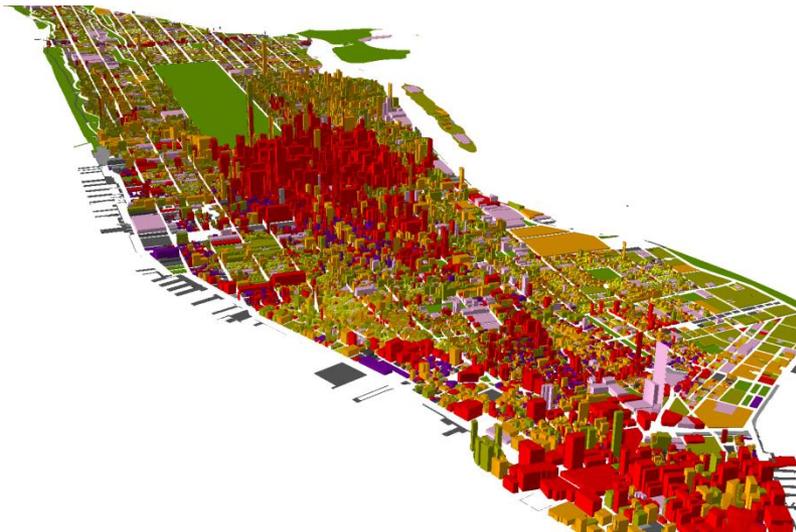
VIEW DATA AND CREATE MAPS



View Imagery



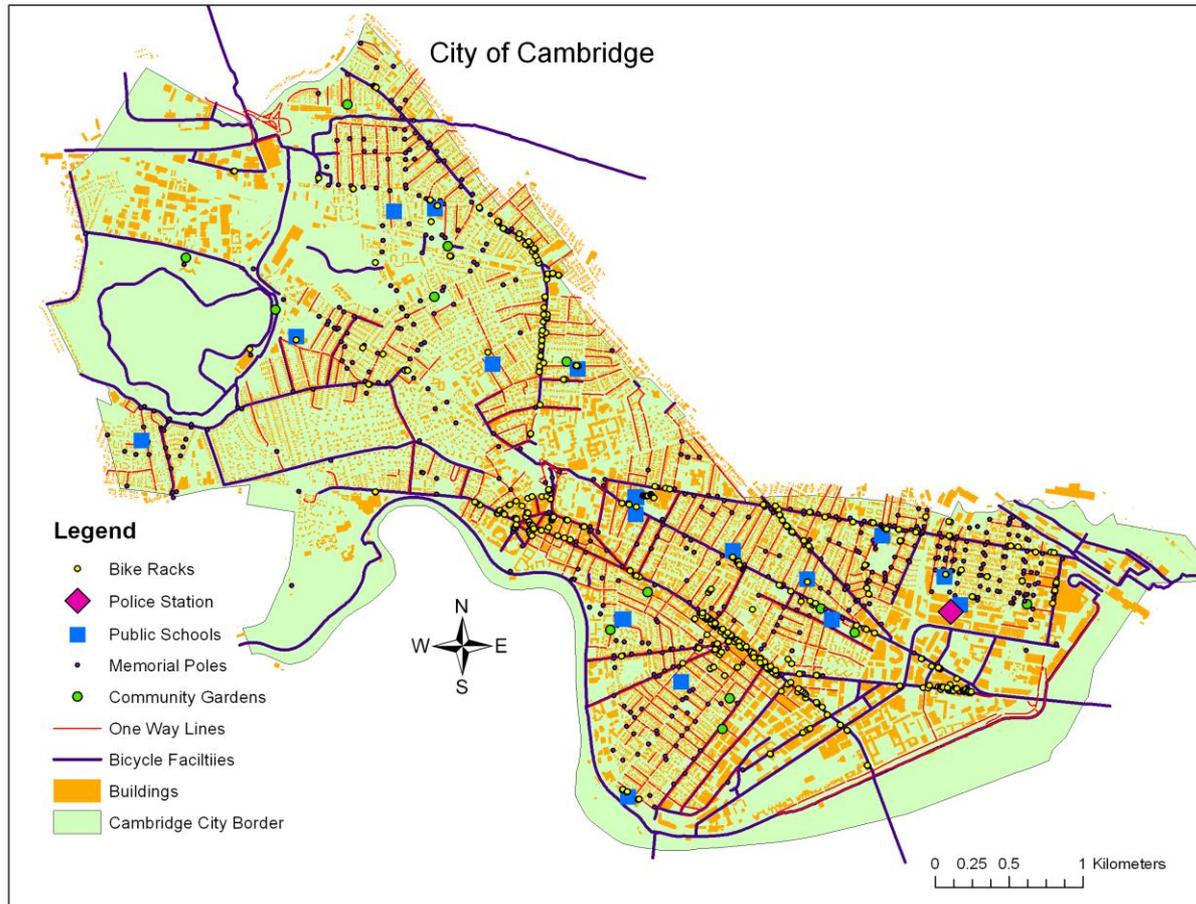
Create 3D models



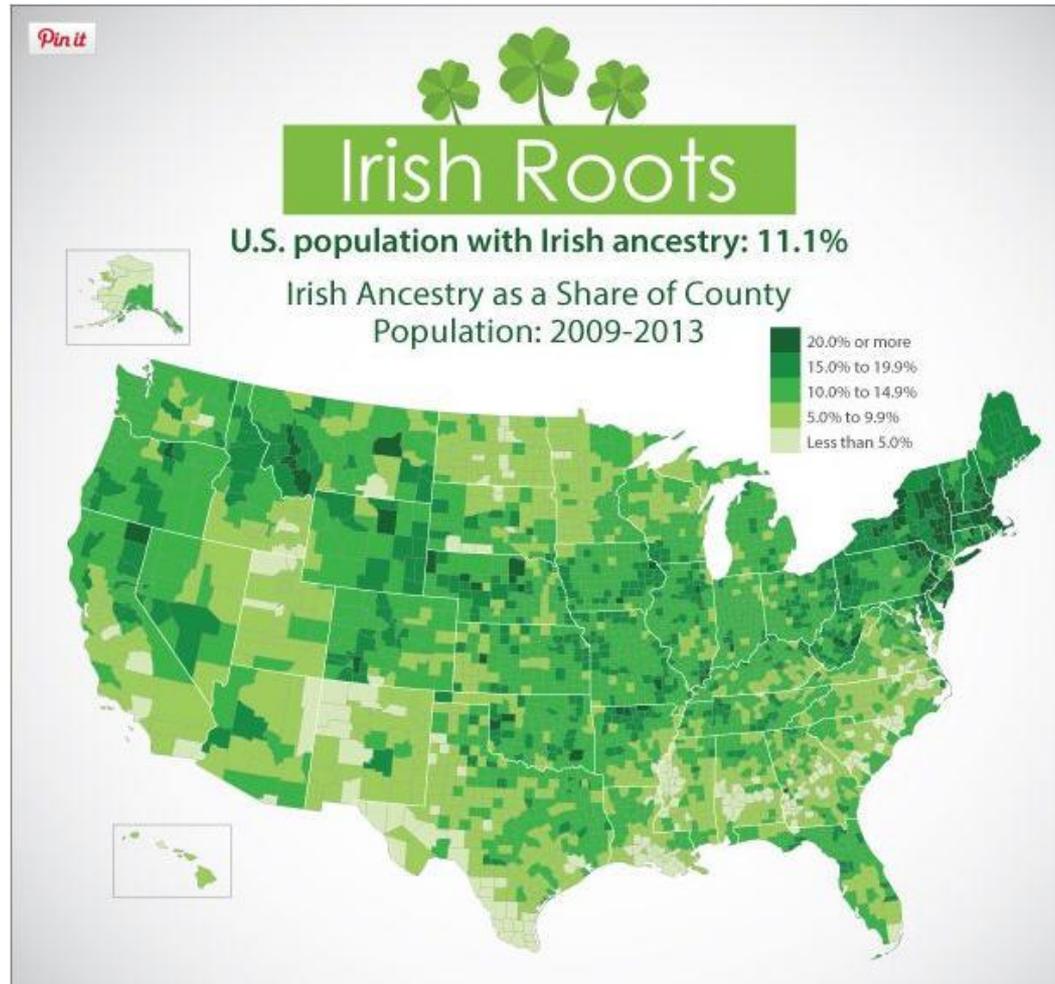
Create Maps



Create Maps



Create Maps



PERFORM ANALYSIS

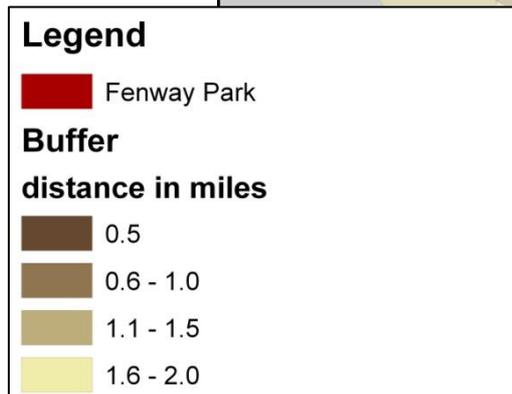
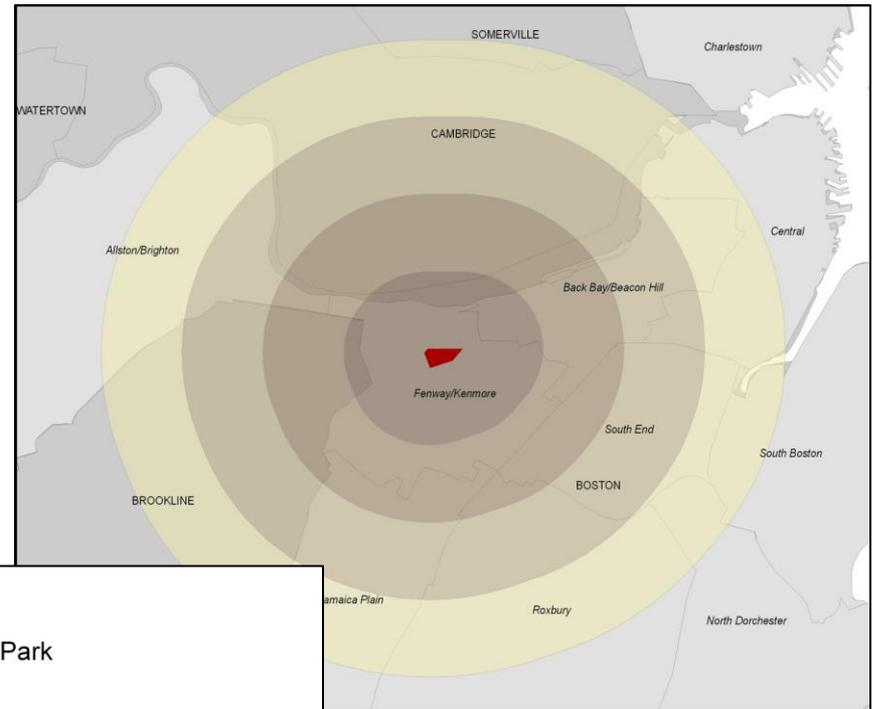


Create Buffers

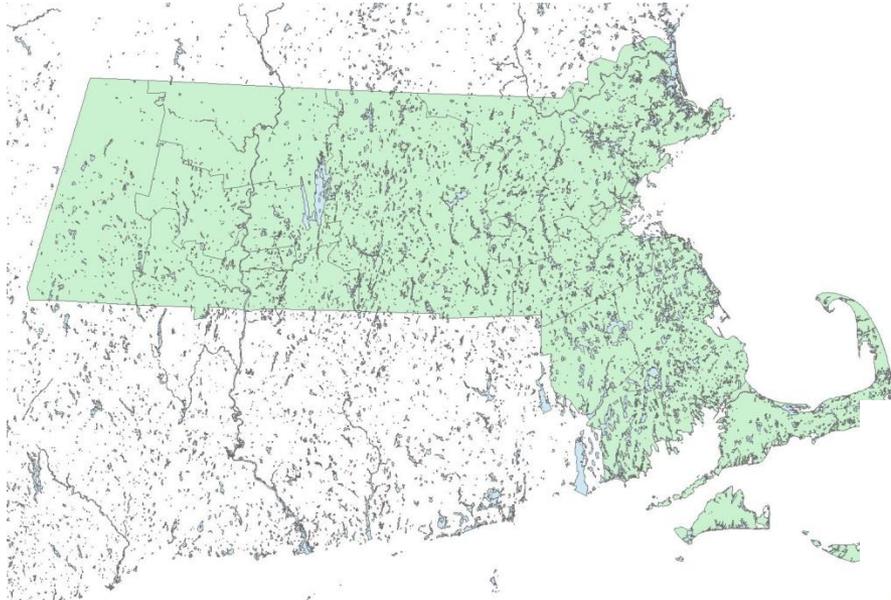
Calculate what is

- Inside
- Outside
- Within a certain distance

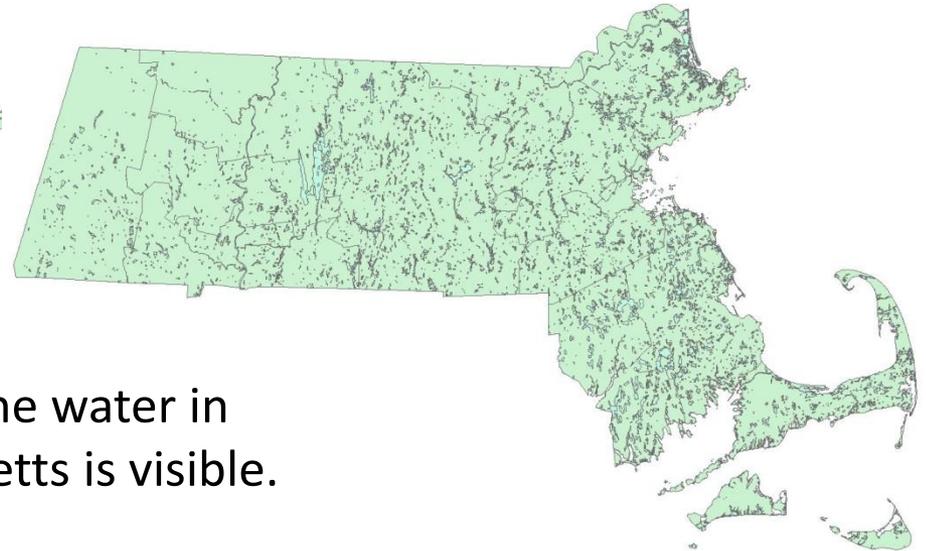
Buffers in ½-mile increments around Fenway Park



Clip Features



All the water bodies in the US have been clipped using the Massachusetts state boundary.



Now only the water in Massachusetts is visible.

Network Analysis

Network Analyst - Streets ND

ArcToolbox:

- 3D Analyst Tools
- Analysis Tools
- Cartography Tools
- Conversion Tools
- Coverage Tools
- Data Management Tools
- Geocoding Tools
- Geostatistical Analyst Tool
- Linear Referencing Tools
- Routing
 - Routing Tool
- Spatial Analyst Tools
- Spatial Statistics Tools

Layers:

- test1
- bayareafacilities
- bayareaincident
- bayarealocations
- bayareamultiroutestops
- streets_nd_junctions
- MultipleRoutes
- streets
- streets_nd

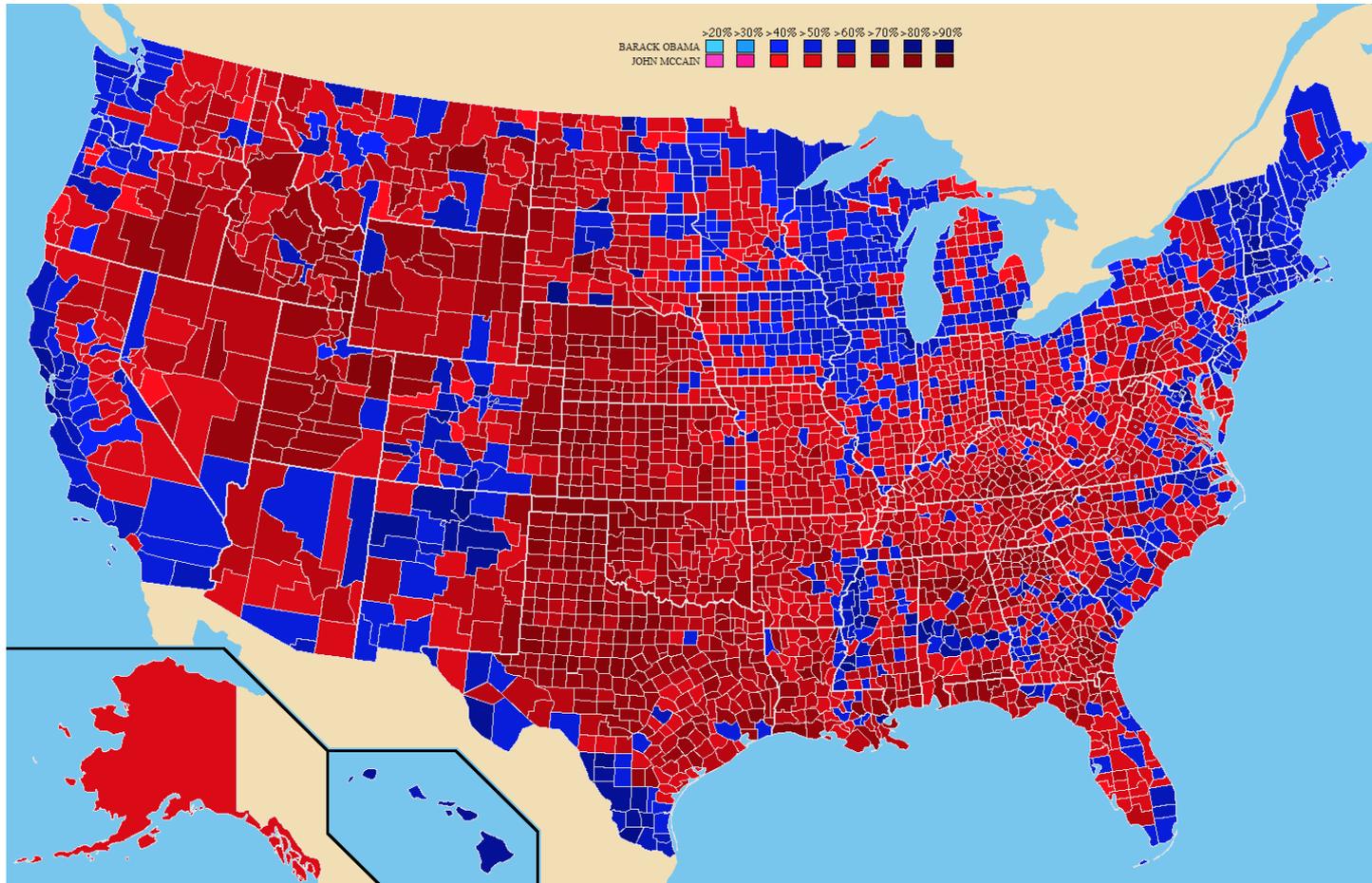
Attributes of MultipleRoutes

Name	FirstStopID	LastStopID	Total_Minu	Total_Mete
Andy's House - Bebel's House	1	2	6.187498	5832.046304
Andy's House - Charlie's House	3	4	3.481358	3257.574274
Andy's House - David's House	5	6	4.862183	4533.184722
Andy's House - Edger's House	7	8	8.659843	8268.948963
Andy's House - Fran's House	9	10	6.770799	6368.689056
Andy's House - Gerry's House	11	12	4.462491	4358.520327
Andy's House - Hanna's House	13	14	9.193034	8579.482104
Andy's House - Ivan's House	15	16	9.677030	9089.794521

Record: 0 | Show: All Selected | Records: 1 (out of 8 Selected) | Options

122°29'1.02"W 37°47'54.85"N

Spatial Statistics



Courtesy of Tilden76 on Wikipedia at <http://commons.wikimedia.org/wiki/File:2008prescountymap.PNG>. License CC BY 3.0

Analyze Raster Data



Digital Elevation Model (DEM): A sampled array of elevations for a number of ground positions at regularly spaced intervals

Use it to:

- Calculate rivers and watersheds,
- Create contour lines
- Determine viewsheds



...and More!

- Calculate area and volume
- Join data based on a common attribute (ID, name, etc.) or its spatial location
- Find where data layers intersect
- Find the nearest features
- Perform surface analysis
 - Contour
 - Slope
 - Hillshade
 - Viewshed
 - Hydrology



Where do I find GIS data?



Data Sources

- MIT sources
 - [GeoWeb](#): use any web browser (includes data downloads as well as DVDs and Maps in the library)
- Internet
 - <http://libguides.mit.edu/gis> (Links to data sources)
- Create your own
 - GPS, digitizing, etc.

Not finding what you want? GIS data purchase requests?
Contact GIS Help.



GeoWeb – search 2000+ layers of MIT hosted GIS data and data from other schools.

Search interface for MIT GeoWeb showing search results for "boston".

Search: boston

Filters:

- Limit results to visible map
- Hide restricted layers from other institutions

Institution

MIT	186
Harvard	171
Tufts	54
MassGIS	20
Berkeley	0

Data Type

Scanned Map	145
Paper Map	133
Polygon	68
Raster	34
Line	23
CD-ROM	13
Point	10
DVD-ROM	5
Undefined	0

Search Results:

- Plan of Boston.
- Plan of Boston.
- Public schools in the city of Boston / Boston Redevelopment Authority.
- Regional Boston [cartographic material] / Boston Society of Architects.
- City of Boston [cartographic material] / Boston Redevelopment Authority.
- Docks Boston 2012
- Sidewalks Boston MA 2012
- Sport Boston MA 2012
- Infrastructure Boston MA 2012
- Buildings Boston MA 2012
- Structures Boston MA 2012
- Parcels Boston MA 2008
- Parcels Boston MA 2007
- Parcels Boston MA 2012
- Walls Boston, MA 2012

1 2 3 ... 29

Map: Google Maps showing the United States and surrounding regions. The search results are displayed as a list of layers on the left side of the map.



GIS Services links to data: libguides.mit.edu/gis

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Geographic Information Systems (GIS)

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Home

MIT Geodata Repository
CDs in the library
General Data for the world
General Data by country (non-US)
General Data for the US (nationwide) available for use during Rotch's operating hours. GIS listed below for GIS help - no appointment necessary.
General Data for the US (by state)
Buildings and Transportation
Businesses
Census/Demographic Data
Elevation/Bathymetry
Energy and Environment
Geology up an appointment. Our email address is gishelp@mit.edu.
Imagery
Land use and Land cover
Water

GIS Assistance

The GIS laboratory, housed on the software is for use by the MIT Com

GIS Help Hours:

May 19th- 30th: by appointment
June 2nd - August 29th: Mon-Fr
There will be no lab hours on Thur
If you cannot make these times, en

Contact Us

gishelp@mit.edu

Maps

- Maps Guide
Click here to access our guide to maps.

Data Management

- Data Management
Learn more about how to manage your data.

Contents

- Home
- About GIS Services
 - Staff
 - Service Guidelines
 - The GIS lab
- Find Data
 - MIT Geodata Repository
 - CDs in the library

News

We are offering two GIS workshops in July. See our [Current Workshops](#) page for more information and to register.

New GeoWeb is here! Check out the new interface which includes a simpler search, faceted browsing, and information about our CD and DVD collection in the GIS lab, making it easier to find all our geographic data with one search.

Access **LandScan data from 2000 to the present**. World population data in a 1km grid is now available online.

Want to learn MIT GIS Services news as soon as it is released? [Sign up for our listserv](#)

Get Started

Download ArcGIS and the MIT Geodata Search Tool for ArcGIS. MIT Certificates are required to download this software. Installation instructions are here (.pdf format).

OpenStreetMap.org

The screenshot displays the OpenStreetMap.org interface. At the top, there are tabs for 'View', 'Edit', 'History', and 'Export'. A search bar is located on the left side. The main area shows a detailed street map of Washington, D.C., with various landmarks and street names labeled. The sidebar on the left contains the following text:

OpenStreetMap
The Free Wiki World Map

Search

examples: 'Alkmaar', 'Regent Street, Cambridge', 'CB2 5AQ', or 'post offices near Lünen' more examples... Where am I?

OpenStreetMap is a free worldwide map, created by people like you.
The data is free to download and use under its open license. Create a user account to improve the map.

Help
Help Centre
Documentation
Copyright & License

Community
Community Blogs
Foundation
User Diaries
GPS Traces
Map Key

Make a Donation

Hosting is supported by the UCL VR Centre, Imperial College London and Bytemark Hosting, and other partners.

Open data! Anyone can contribute and download. ³⁶

Data Formats

- ArcGIS can read many formats, including:
 - Shapefile, personal geodatabase (Access), file geodatabase (ESRI)
 - Image formats (JPG, TIF, GEOTIF, etc.)
 - CAD (DXF and DWG)
 - KML/KMZ files (from Google Earth)
- Data can be exported from ArcGIS to a variety of formats, including:
 - KML
 - CAD
 - Adobe Illustrator
 - TIF
 - JPG



Create your own Data: Map Coordinates or Addresses

Geocode Addresses:

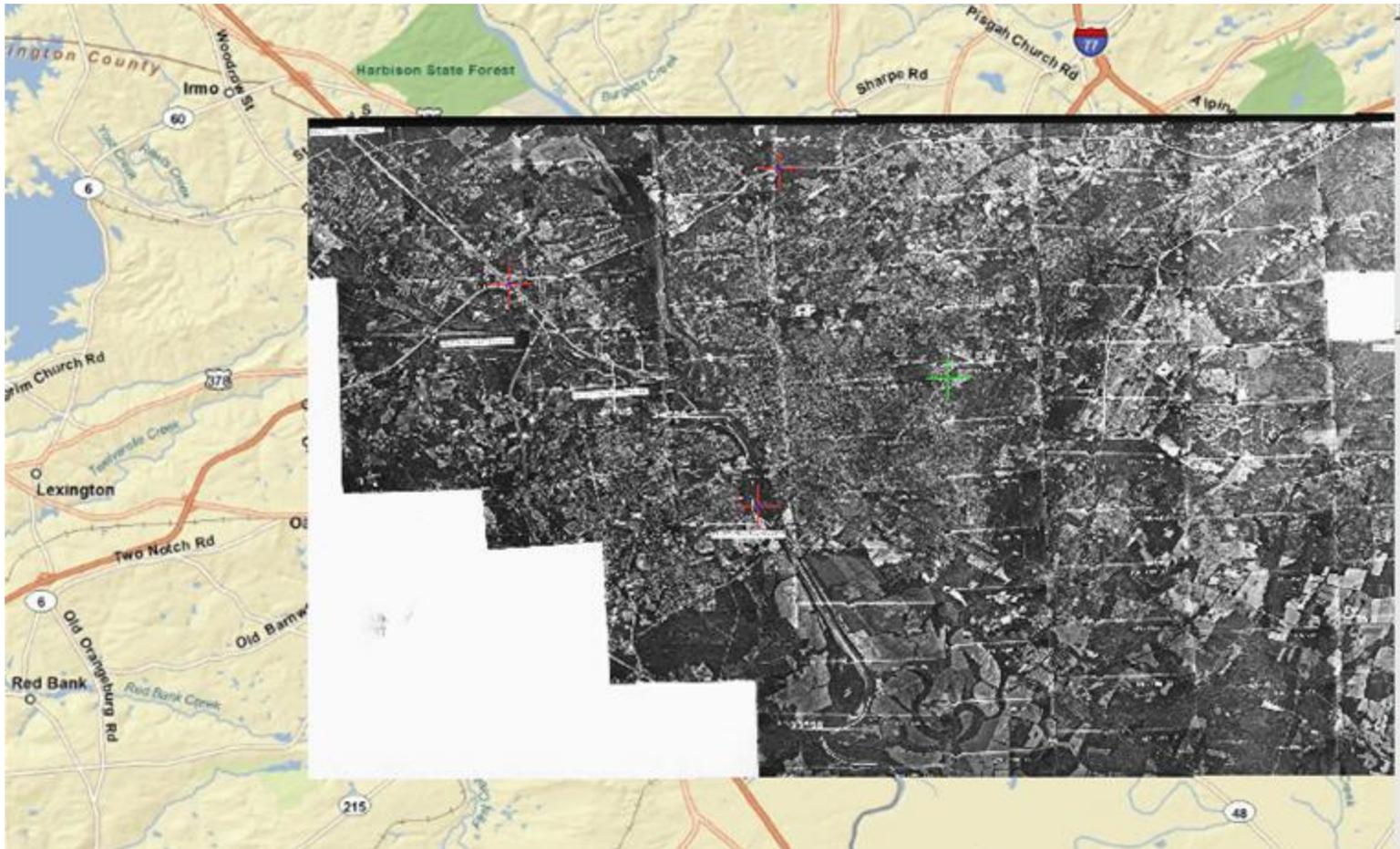
- 77 Massachusetts Ave. Cambridge, MA 02139

Add XY data:

- 71.093458 W
- 42.359097 N



Create your own Data: Georeference maps and images



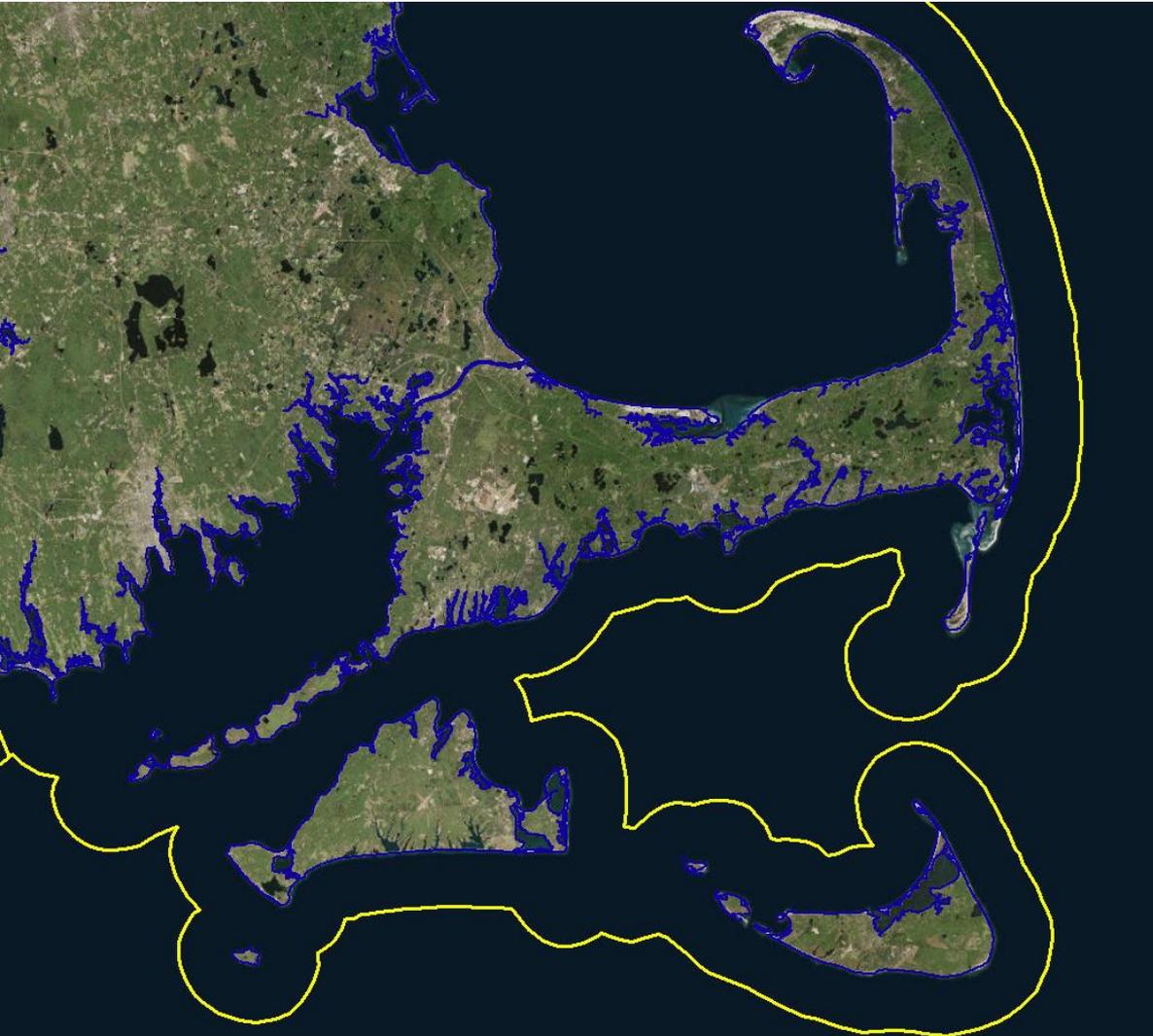
Collect Your Own Data

Global positioning system (GPS) devices are available for checkout from the Rotch Library circulation desk.



Courtesy of Nachoman-au on Wikipedia at https://en.wikipedia.org/wiki/Global_Positioning_System#/media/File:Magellan_GPS_Blazer12.jpg. License CC BY 3.0.

Data Sources



Data from different sources, covering the same area, can look very different. Evaluate scale, accuracy, and file size when selecting data for a project.

The yellow line is the coastline from the US Census state boundary file. Blue is the coastline from MassGIS.



Metadata

- Information about the data layer
- Read the metadata to determine who created the data, when it was created, what the codes in the table mean, if there are constraints on how it can be used, etc.
- You can find metadata:
 - Downloaded with your data layers
 - On the website where you got your data
 - Sometimes you may need to contact the data provider to get metadata
- Metadata is most commonly in html/xml format, text files, or in a table format, such as excel or csv.



Metadata

World (Countries, 2005)

Institution

MIT

Data Type

Polygon

Theme Keywords

polygon countries international boundaries coastlines
area international codes status population boundaries
society

Place Keywords

World



Download FGDC Metadata

- ⊕ Identification Information
- ⊕ Metadata Reference Information
- ⊕ Spatial Data Organization Information
- ⊕ Spatial Reference Information
- ⊕ Entity and Attribute Information
- ⊕ Distribution Information

In GeoWeb, expand each category to read the metadata.

Metadata

Entity and Attribute Information

SDE_DATA.INT_A1CNTRY_2005

ObjectID

Attribute Definition Internal feature number.
Attribute Definition Source ESRI

FIPS_CNTRY

Attribute Definition The FIPS code (two-letter) for the country.
Attribute Definition Source Department of Commerce, National Institute of Standards and Technology

GMI_CNTRY

Attribute Definition The country code (three-letter) for the country from Global Mapping International.
Attribute Definition Source Global Mapping International

ISO_2DIGIT

Attribute Definition The country code (two-letter) for the country from the International Organization for Standardization.
Attribute Definition Source International Organization for Standardization

ISO_3DIGIT

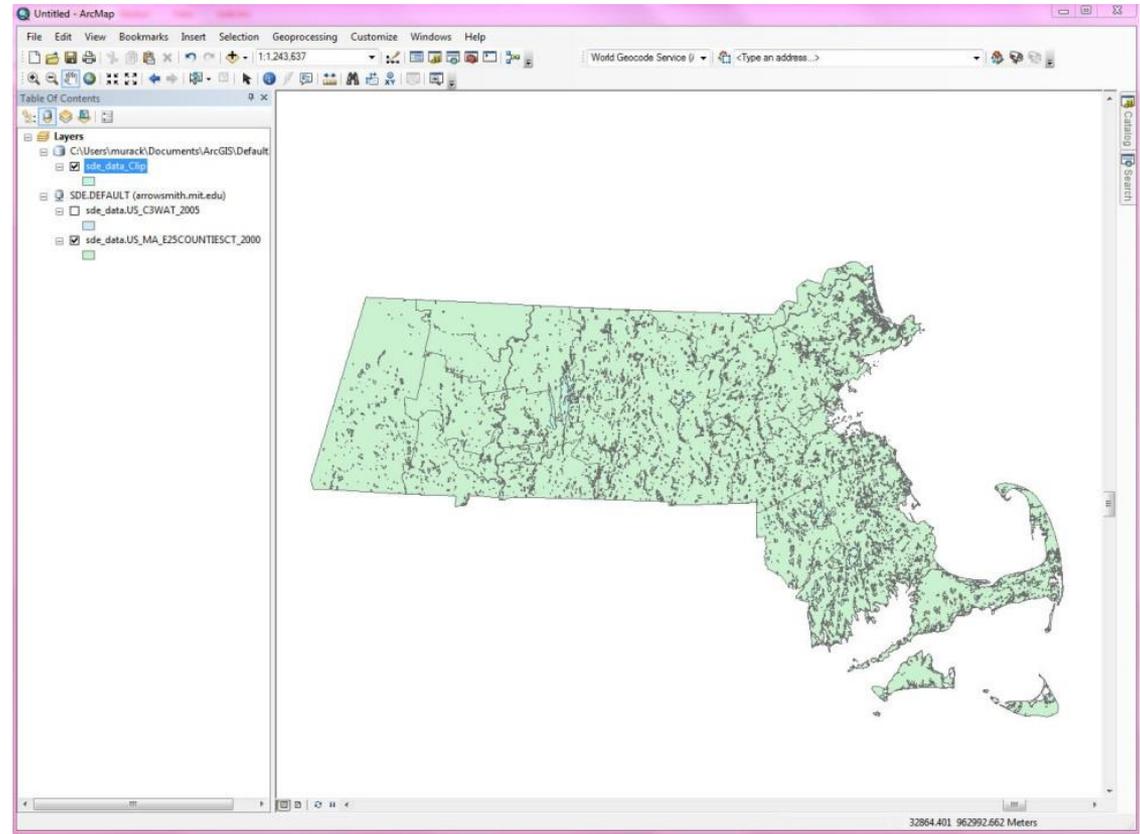


What software can I use?

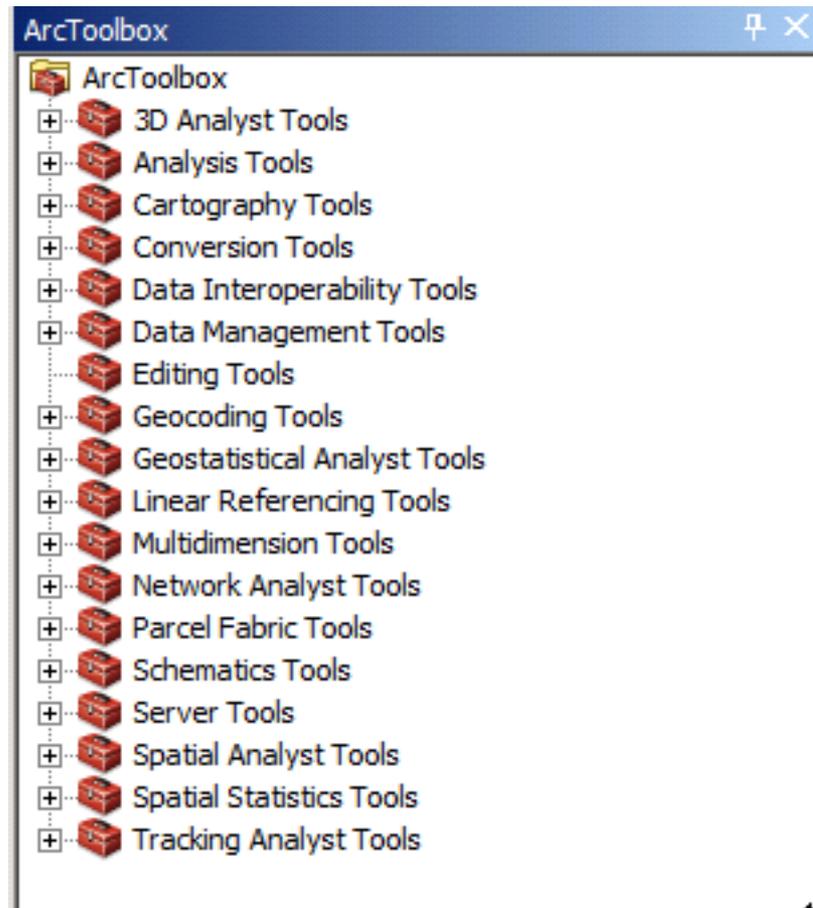


ESRI ArcGIS: ArcMap

- Provides the most tools for processing data, analysis, and creating maps
- Comprehensive support through our academic license

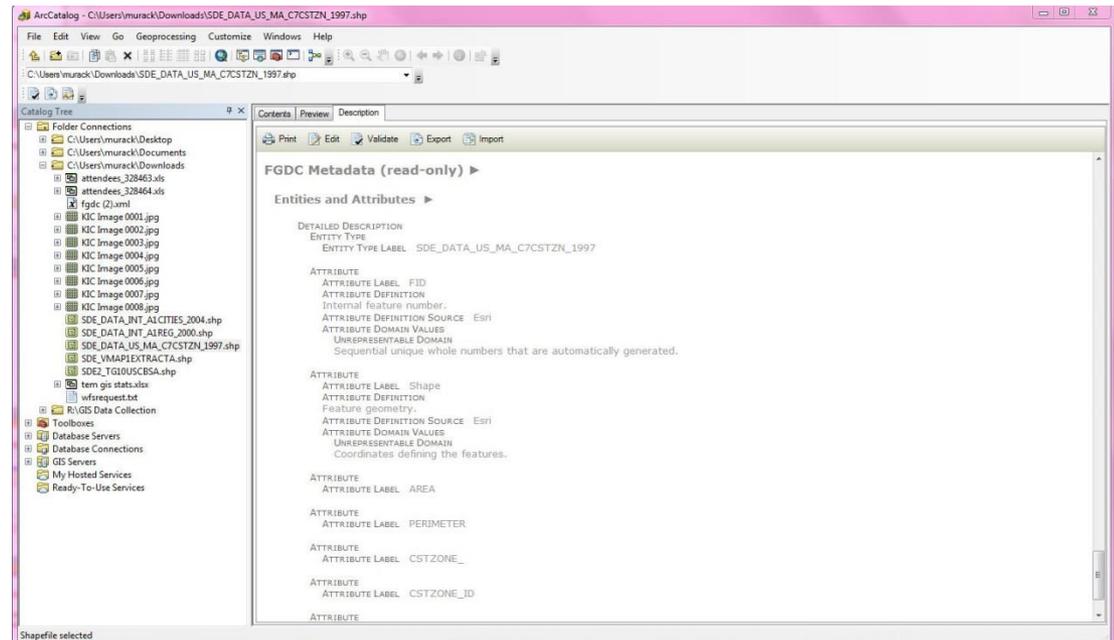


ArcToolbox



ESRI ArcGIS: ArcCatalog

- Manage files and folders
- Create new shapefiles and geodatabases
- Preview files
- View metadata in format of choice
- Create metadata so your data can be understood and shared with others
- Save metadata files as XML, TXT, HTML, or SGML



Open Source Software

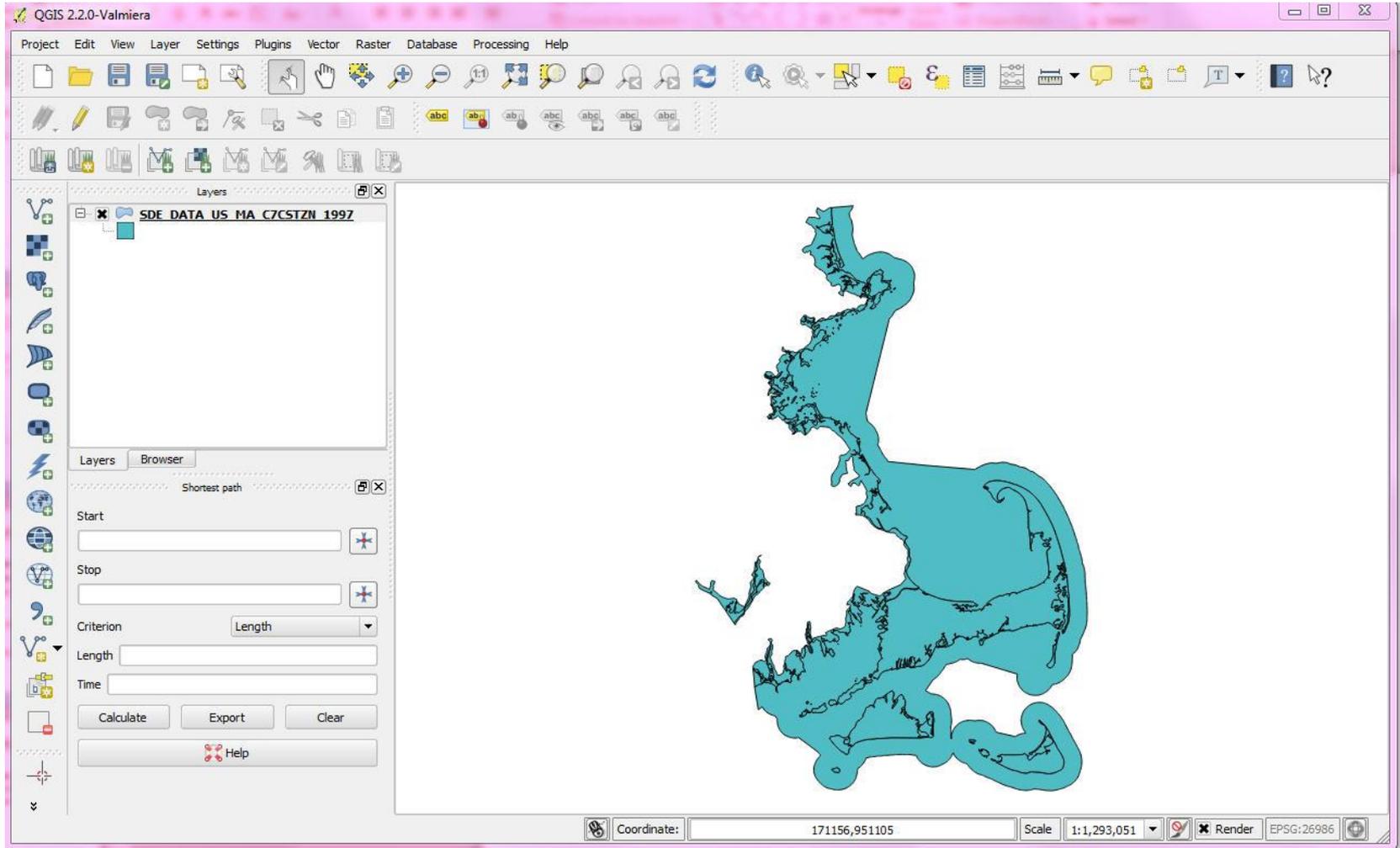
The source code is made available under a license that allows the modification and redistribution of the software at will.

For a more in-depth definition, visit the Open Source Initiative:

opensource.org/docs/definition.php



QGIS



Data Management Tips



Data Management Tips

GIS projects tend to generate **many files**, which are generally **large in size**. For file naming:

- Use file names that represent the file (default names like Export_Output are not helpful if you need to come back to your project later).
- Some software programs and tools may have file name constraints (e.g. an eight character limit without spaces). Watch out for this with ESRI ArcToolbox.
- Backup Your Data!



Data Management Tips

Keep detailed notes about:

- Data sources
- Licensing constraints
- Data processing steps (ModelBuilder creates visuals of your procedure)
- What is stored where
 - The GIS project maintains links to the individual data files (the data is not embedded in the map document itself)
 - GIS formats, like shapefile (SHP), have many files that are linked together and must stay together in order to function
- Descriptions of the files you create and use (ArcCatalog has built-in tools for creating and editing metadata)



Exercise Overview

- Navigating the software interface
- Finding and adding data, including basemaps
- Accessing attribute information
- Symbolizing your data layers
- Selecting data by attribute and spatial location
- Creating new GIS data
- Designing a simple map



MIT OpenCourseWare
<http://ocw.mit.edu>

RES.STR-001 Geographic Information System (GIS) Tutorial
January IAP 2016

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