Geospatial Problem Solving

Introduction

Image from NASA: https://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_transparent_background.png#filelinks

WV VIEW

AmericaView
Empowering Earth Observation Education
AmericaView.org - Est. 2003

This lecture provides an introduction to geographic information systems (GIS), geographic information science (GISc), and geospatial problem solving.

Module Topics

1. Introduce course
2. Defining GIS and GIScience
3. Functions of a GIS
4. Components of a GIS
5. Geospatial job market

2

These are the topics covered in this module.

Introduction to Course

Course Objectives

1. Describe and critique how computers store geospatial data using the vector and raster data structures.
2. Find geospatial data using the web.
3. Describe and quantify uncertainty associated with data and assess the suitability of data for a specific task.
4. Use a variety of data, methods, and software tools to address a question with a spatial component.
5. Assess and evaluate the suitability of specific spatial analysis techniques for addressing a spatial problem.
6. Produce, explain, and document spatial models.
7. use the ArcGIS Pro commercial software package and have gained enough knowledge with the use of this software tool to further your knowledge of its use independently.
8. use the QGIS open-source software package and have gained enough knowledge with the use of this software tool to further your knowledge of its use independently.

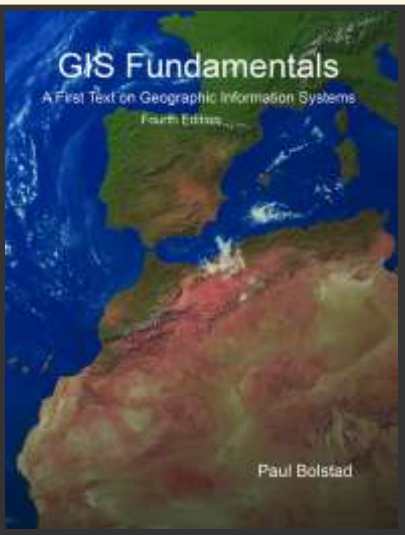
4

These are the learning objectives of the course.

What is a GIS?

A computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information

-Paul Bolstad



https://www.xanedu.com/higher-education/educators/custom-books%20catalog/gis_fundamentals/

5

This slide provides a definition of GIS as provided by Paul Bolstad in the *GIS Fundamentals* text.

A geographic information system is a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information.

Geographic Information Science, GIScience, or GISc is the science behind geographic information systems and working with spatial data.

This course will discuss both GIS and GIScience.

Example Products We Generate

- Digital data representing map features
- Paper maps
- Interactive maps
- 3D renderings
- Websites and data dashboards
- Data services
- Workflows and methods
- Reusable code/scripts
- Reusable models
- Documentation and metadata
- Research papers

6

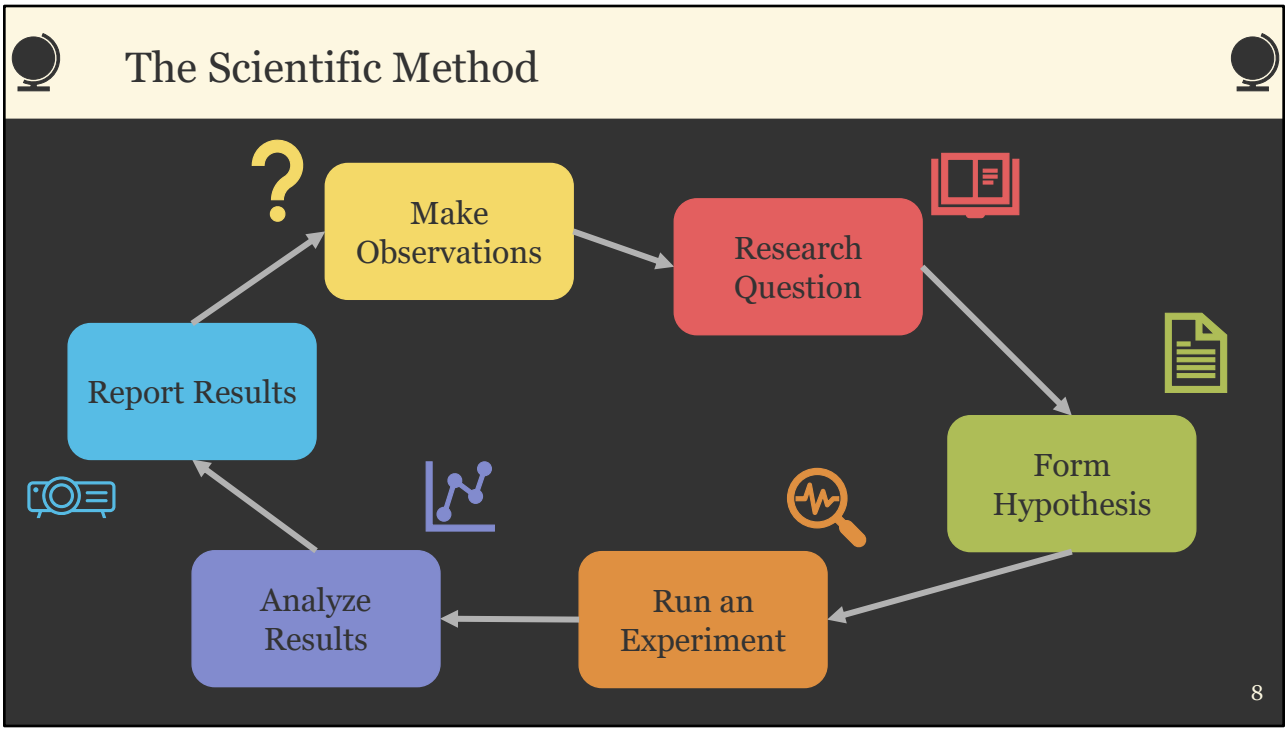
Geospatial professionals create a variety or products. This slide provides a list of general products that we produce.

Example Questions We Answer

- What map features meet certain criteria?
- What is the most suitable location for a project?
- Where is a feature or organism most likely to be found?
- Where is a phenomenon most likely to occur?
- How is a phenomenon likely to change in the future?
- What is the best way to travel between two points along a network?
- What is the best means to represent a spatial feature or phenomenon digitally?
- What is the most effective way to visualize map data?
- How accurate or precise is a map product or spatial prediction?

7

We also answer a variety of questions using geospatial data and analysis methods.



Geospatial science makes use of the scientific method to answer questions. This is the primary framework we use to conduct our work.

The scientific method begins with observation and the formulation of a question. Background research may indicate that this question has already been answered and is not in need of additional investigation. However, if there appears to be a knowledge gap, the researcher can form a hypothesis and conduct an experiment to test it. The results of the experiment can then be analyzed, and the results can be presented or reported.

The scientific method may seem lofty, but we use this means of answering questions and understanding the world on a day-to-day basis. For example, you may observe that your car is making a strange noise and question why this is happening. You could then do some background research to determine what could be the cause. If the background research does not pinpoint the problem or only helps to narrow down the problem to a list of potential causes, you can then form a hypothesis and test it. Your hypothesis might be that the noise is caused by a bad wheel bearing. Your experiment could consist of observing whether or not the noise occurs all the time or just when the vehicle is moving. You could determine if it changes pitch as your speed varies. Lastly, you could lift the car and see if the tire seem loose. If your experiments indicate that it is indeed the wheel bearing you could then conclude that your hypothesis is likely

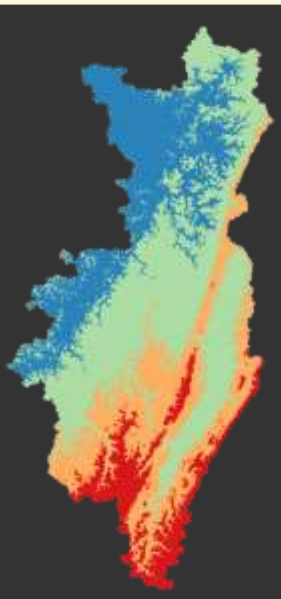
true and proceed to replace it or take it to the shop.

Scientific investigations often lead to more investigations. If your hypothesis is not supported by your experiment and subsequent analysis, then you may form a new hypothesis and design a new experiment to test it. If your experiment supports your hypothesis then new or more specific questions may be raised that can lead to more research, hypothesis formulation, and experimentation.

In short, the scientific method offers a rigorous and systematic means to explore our world. Since experimentation yields data that needs to be analyzed, scientists can benefit from developing skills in data science and data scientists can benefit from thinking in terms of the scientific method.

Important Geospatial Skillsets

1. Spatial problem solving
2. Spatial analysis
3. Software troubleshooting
4. Statistics
5. Spatial predictive modeling
6. Database management
7. Web GIS
8. Python scripting
9. JavaScript scripting
10. Cartography/Map design
11. Graphic design
12. Remote sensing/Image interpretation
13. GPS technology
14. Integration of AI



9

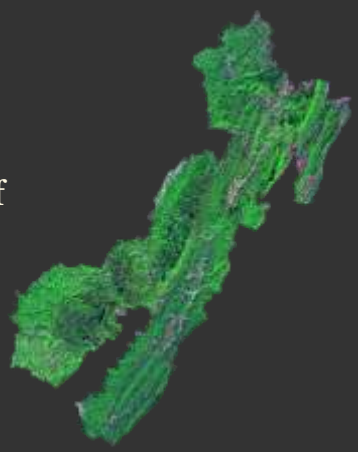
Here are a list of some key, marketable job skills in the geospatial sciences.

No one can do all of these things. If you are hoping to work in this field, I would recommend focusing on some key skills to develop and market. Specifically, if you are interested in data analysis, it would be worth learning Python scripting. If you are interested in data management, I would try to learn some Structured Query Language or SQL. If you are interested in web development and web mapping, learn some HTML, CSS, and JavaScript.

As you advance through your career you will continue to develop skills. Also, new technologies and methods will require you to learn new skillsets. Although this can be frustrating, it is exciting to be involved in a rapidly growing and developing discipline.

Hot Topics and Current Developments

1. 3D GIS/geovisualization
2. Virtual reality/augmented reality
3. Drones
4. Big data/data mining
5. Parallel computing
6. Machine learning/artificial intelligence/deep learning
7. Spatial predictive modeling
8. Laser scanning
9. Hyperspectral data
10. Real time GIS
11. Expanding the use of geospatial science



10

As already mentioned, the geospatial technologies and sciences are developing fast.

Some current trends are 3D GIS and geovisualization along with virtual and augmented reality. With the advent of VR headsets and faster computing, 3D GIS has advanced quickly and has many applications including video games and animation.

Drones have also had a big impact on our discipline. We are now able to collect, process, and analyze our own data. Further, it is becoming easier to collect and process drone data. A wider variety of sensors can be attached to drones, including multispectral sensors, LiDAR, and thermal sensors.

Big data, data mining, and data analytics are changing many fields, and the geospatial sciences is no exception. Related technologies include parallel computing, machine learning, artificial intelligence, and deep learning. We are now able to extract information from large datasets to make more informed decisions. These techniques have already been applied to spatial predictive modeling.

In remote sensing, we are seeing greater availability of quality datasets such as LiDAR and hyperspectral imagery. Private companies are launching

microsatellite constellations to collect high spatial resolution data on a daily basis. We are still learning how to effectively work with and leverage these new datasets.

With broadband and wireless technologies, it is becoming easier to collect and analyze spatial data in real time.

More disciplines are finding a use for these technologies, including business and medicine. The self-driving car industry relies heavily on geospatial data and GIS.

It is truly an exciting time to work in this field!

Functions of a GIS

1. Capture

https://commons.wikimedia.org/wiki/File:Bad_gdop.png

https://www.usgs.gov/landsat-missions/landsat-8

https://commons.wikimedia.org/wiki/File:Interspect_UAV_B_3.1.png

12

A fully functional GIS should be able to capture, store, query, analyze, and display spatial data.

This slide shows a variety of methods that can be used to capture new geospatial data including GPS technologies, digitizing, and collection using a variety of sensors and platforms.

GIS, Remote Sensing, GPS

https://www.usgs.gov/landsat-missions/landsat-8

https://commons.wikimedia.org/wiki/File:Bad_gdop.png

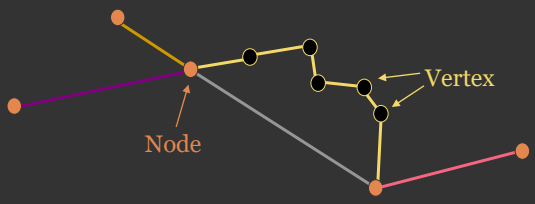
13

Remote sensing and GPS can be used to capture data. They are considered sister disciplines of GIS.

Remote sensing is collecting information without coming in contact with the object of interest. Examples include collecting images from satellite-based sensors, collecting thermal data from drone platforms, and collecting elevation data using lasers from an aircraft platform.

GPS involves using multiple satellites and radio signals to find your location on Earth.

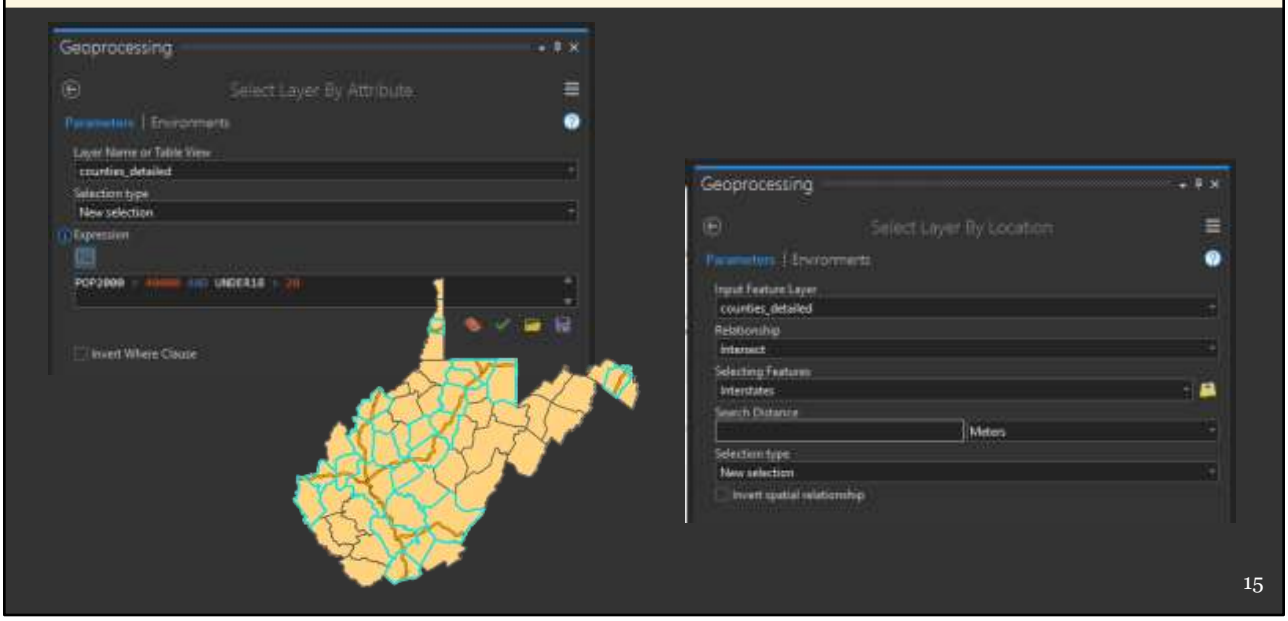
2. Store



14

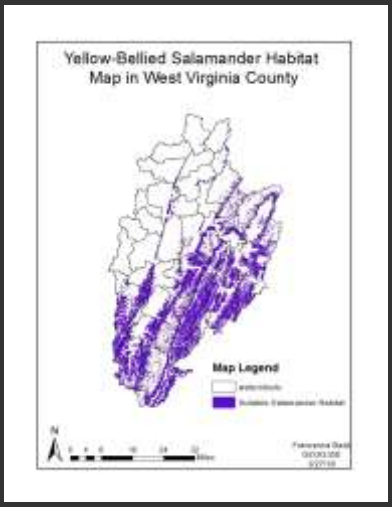
Data storage can occur on local disks, on servers, or in the cloud. In a later module we will discuss the data types used to store spatial data.

3. Query



In this class, we will use Structured Query Language (SQL) to query our data and find features that meet our criteria. This is the same query methods used in a traditional database. However, now we have access to spatial, or location, information. So, it is also possible to query our data based on spatial characteristics.

4. Analyze



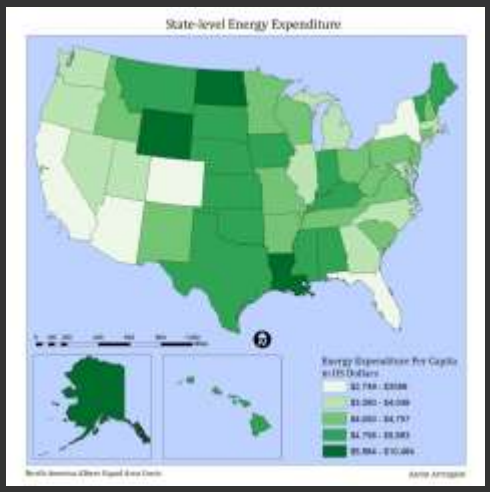
Map by Francesca Basil

- Directions
- Proximity
- Suitability
- Meet defined criteria
- Likelihood
- Best locations
- Worst locations
- Etc.

16

The back half of this course is devoted to spatial analysis methods including vector spatial analysis, raster spatial analysis, digital terrain analysis, geospatial modeling, ArcGIS ModelBuilder, weighted overlay, spatial statistical analysis, and spatial interpolation.

5. Display



Map by Aaron Arrington

Image from Google Earth

17

In this class, you will learn to produce map layouts. The goal of a paper map is to communicate information to an intended audience. So, we will learn to produce audience specific maps. Note that for more practice designing maps, I would recommend a digital cartography course.

There are other ways to display our map data including 3D visualization, augmented reality, and virtual reality.

Components of a GIS

Components

1. People
2. Data
3. Hardware
4. Software
5. Methods/Protocol

19

A GIS requires people, data, hardware, software, and methods/protocols.

Courses such as this one train you to use the appropriate data, hardware, software, and methods/protocols to address questions that have a spatial component.

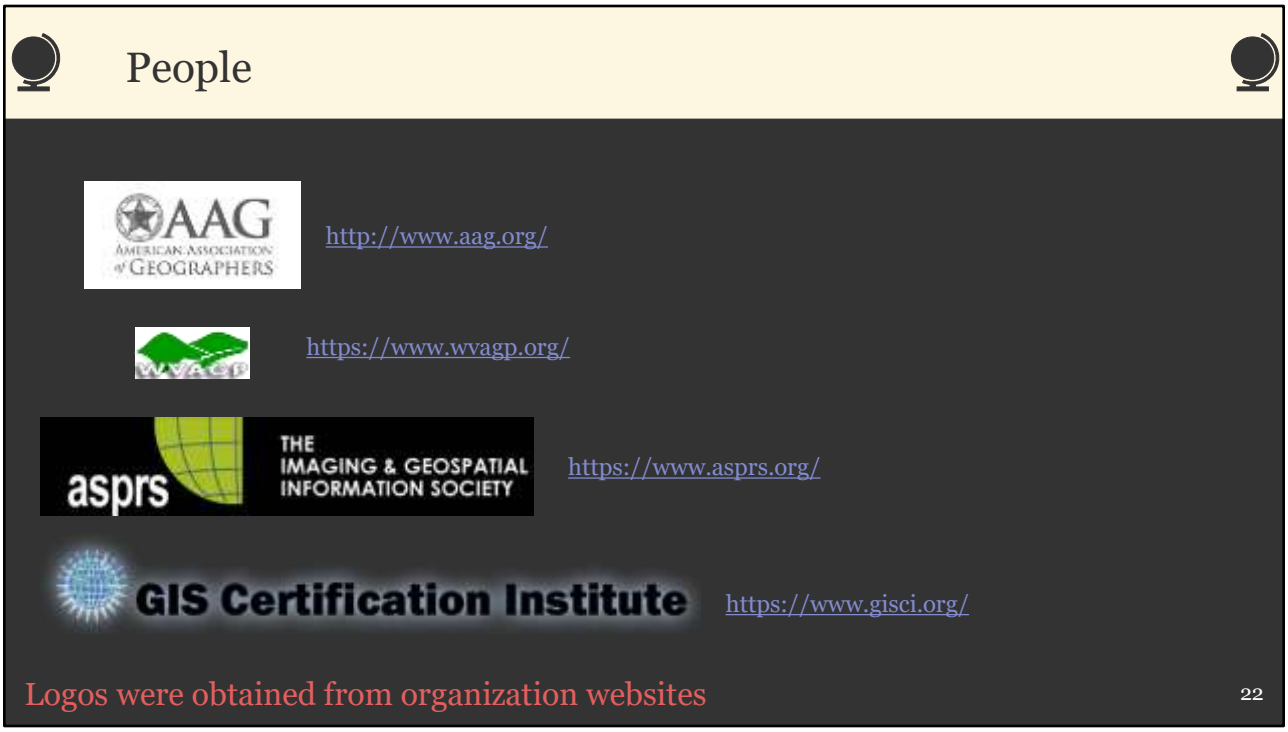
In this class, we use of the Environmental Systems Research Institute's ArcGIS software package. The ESRI software is the standard GIS software used across the globe.

However, there are other software packages available. Some of these software tools are open-source and free, including Quantum GIS (QGIS) and GRASS.

Hardware

21

We use a variety of hardware in GIS including computer workstations, servers, field computers, GPS receivers, digital sensors, and laser scanners.



If you are interested in becoming a GIS professional, there are a variety of professional organizations that you can join or become involved in including the West Virginia Association of Geospatial Professionals (WVAGP), the American Society of Photogrammetry and Remote Sensing (ASPRS), and the Association of American Geographers (AAG). Note that these organizations may offer student discounts for membership fees and conference fees.

Geospatial Job Market

Geospatial Job Market Websites

http://www.gjc.org/

https://www.gisjobs.com/

https://www.mygisjobs.com/

Job titles include:

GIS Technician
GIS Analyst
Remote Sensing Analyst
GIS Programmer
GIS Web Developer
Aerial Survey Technician
Survey Technician
Image Analyst
Etc.

24

Here are some examples of geospatial job titles.

I would recommend the GIS Jobs Clearinghouse if you are interested in searching for geospatial career opportunities: http://www.gjc.org/. Other websites include GISjobs.com and MyGISJobs.com

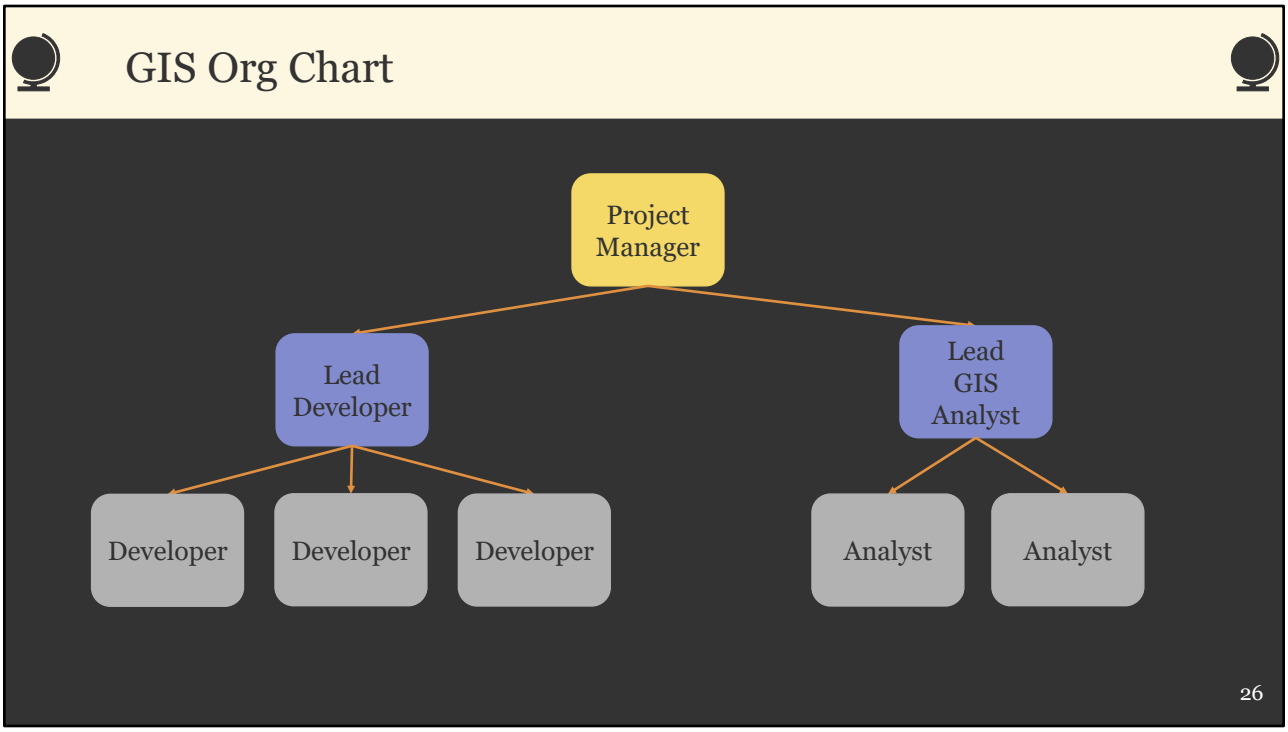
Who hires geospatial professionals?

- Local, state, and federal government
  - County assessors' offices
  - WVDEP, WVDNR, WVDOT, WVU
  - US Census, USDA, Bureau of Land Management, Department of Defense, EPA
- Surveying companies
- Aerial survey companies
- Consulting companies
- Higher Ed.

gisgeography.com/10-gis-career-tips-find-gis-job/

25

Many organizations need geospatial professionals. Here, I have provided some examples.



This is an example organizational chart, or org chart, for a small geospatial working group or office.

Professional Certifications

- Offers GISP (Geospatial Information Systems Professional) Certification

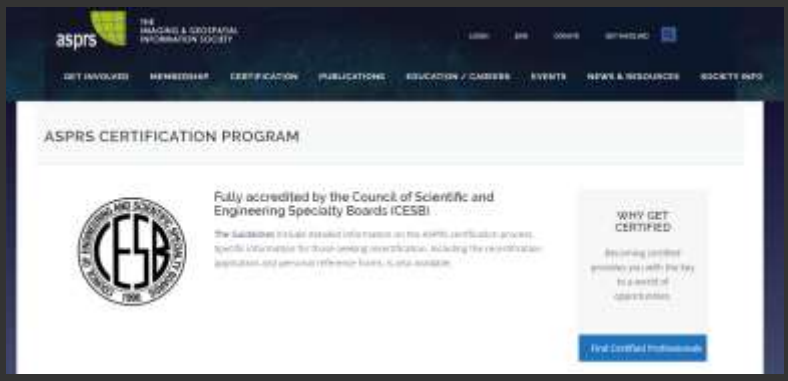
https://www.gisci.org/

27

You can also obtain professional certifications. I recommend looking into the Geospatial Information Systems Professional Certification, or GISP, offered by the GIS Certification Institute.

Geospatial Professional Certifications

- Certified Photogrammetrist
- Certified Mapping Scientist Remote Sensing
- Certified Mapping Scientist GIS/LIS
- Certified Mapping Scientist Lidar
- Certified Mapping Scientist UAS
- Certified GIS/LIS Technologist
- Certified Lidar Technologist
- Certified Remote Sensing Technologist
- Certified Photogrammetric Technologist
- Certified UAS Technologist



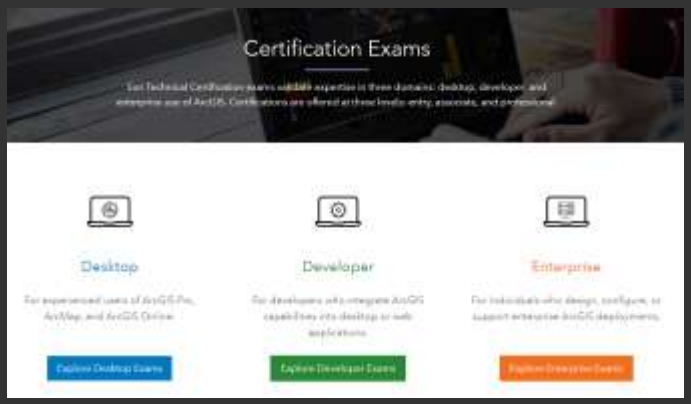
https://www.asprs.org/Certification

28

There are other certification options. For example, the American Society for Photogrammetry and Remote Sensing, or ASPRS, offers many different certifications.

ESRI Professional Certifications

- Technical certification for using ESRI software



https://www.gisci.org/

29

ESRI offers software-specific certifications for their desktop, developer, and enterprise applications.

This is the end of this lecture module.

Please return to the West Virginia View Webpage for additional content.

Thanks! Hope you found this useful.