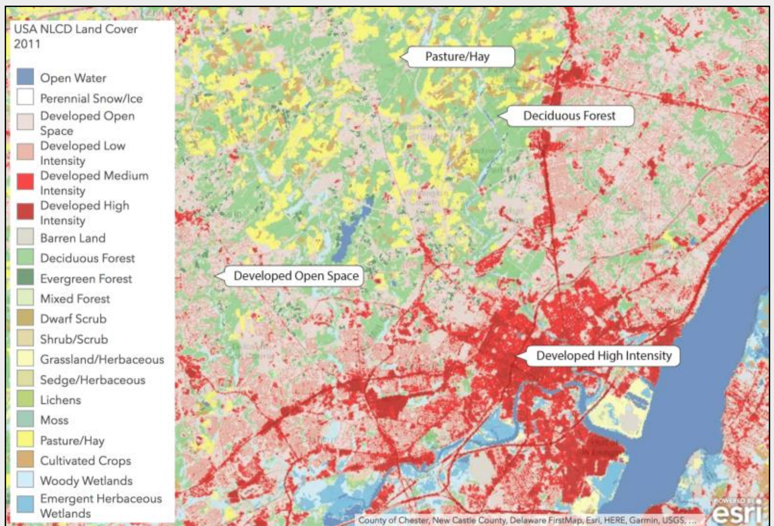
INTRODUCTION:

Scientists, natural resources managers, urban planners, and many others use aerial and satellite imagery to map and understand the Earth's surface. They want to know how ***landcover*** and ***land use*** patterns are changing, and the implications of those changes. Using a combination of aerial and satellite imagery enables both a "big picture" look at landcover and land use, as well as the ability to get in closer for more detail. Using images taken over time helps them understand how the environment is being impacted by human and natural causes.

In order for the imagery to be of value, we often have to "process" it. One of the ways we process imagery is called ***image classification***.

With image classification we determine the types of features on the ground by studying the image. Sometimes we visit sites within the image field of view to be sure that what we think we see is actually what is there. This is often called ***ground-truthing.***



NATIONAL LAND COVER DATABASE - CLASSIFIED IMAGE

Once we think we know what types of features are in the image, we group them into ***classes***. Depending on what we want to know, we may have as few as two classes, or we might describe dozens of classes.

Here are a few examples of classification schemes:

- Dichotomous (2 classes): *1) vegetation* vs. *2) not vegetation*; or *1) land* vs. *2) water*
- Generalized (~ 3 to 10 classes): *1) vegetation*, *2) bare soil*, *3) concrete or asphalt*, *4) water*, *5) buildings*
- Specific (many classes): *1) deciduous trees, 2) coniferous trees, 3) shrubs, 4) grasses, 5) sand, 6) soil, 7) asphalt, 8) concrete, 9) roof material, 10) wooden structures (decks, etc), 11) water,* etc…

The more classes we have, the more detailed we can get. However, we may only want to know what percentage of an image is made up of ***impervious*** surface (things like concrete, asphalt, roofs, etc., where water is not absorbed, but runs off instead). In that case, we would only need two classes - 1) *impervious surface*, and 2) *other*.

Image classification is a very powerful tool for understanding the landscape. It is often done with sophisticated software. In this exercise we will look at a simple method for classifying an aerial image by hand. We will use an image we captured with an Aeropod, though we could use a satellite image or other aerial image as well.

You will need:

- Graph paper
- A color printer
- Pens or pencils
- Crayons or markers
- An aerial image
- Computer access to a spreadsheet program (optional)

Before you start image processing, it is important to make sure you have a suitable image. The image should show a few different types of surface features. It should also be taken with the camera pointing down toward the earth (this is called the ***nadir*** view).

NOTE: If your image is taken with a wide angle lens, you will want to correct it to remove the wide angle barrel distortion. This distortion makes things in the center of the image appear larger than they are, and things at the edges appear much smaller than they are.

There is a simple online tool for this available at Public Lab: [Lens Distortion Tool]

PROCEDURE:

1) Print the image of landscape on graph paper. This should be an aerial image taken with the camera pointed straight down (nadir view). If you can, leave a little room around the image for writing. (Figure 1)

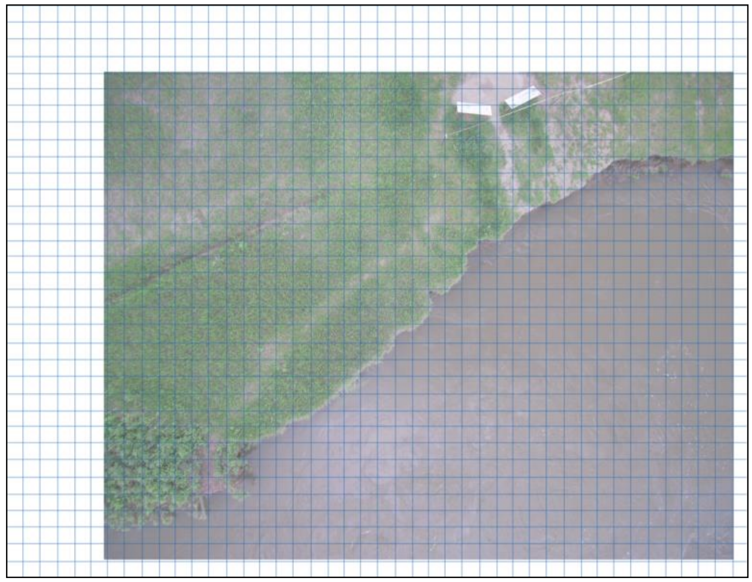


Figure 1

2) Identify the different types (or classes) of features in your image and draw boundaries between them. (Figure 2)

   NOTE: How you define your classes is up to you. You can choose any number of classes. however, for best results in this exercise we recommend between 2 and 10.

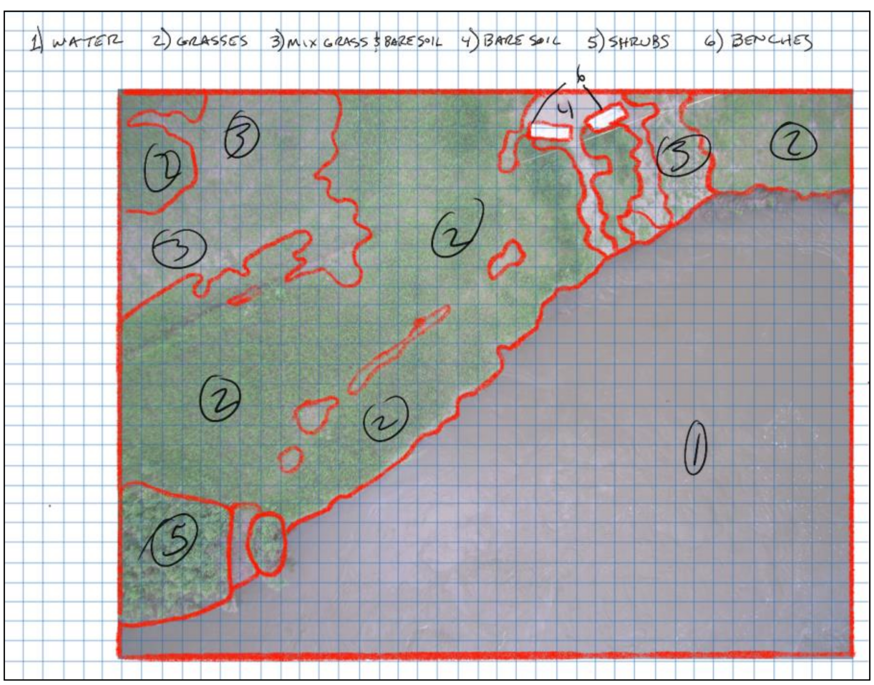


Figure 2

3) Assign a number to each class (1 - vegetation, 2 - bare soil, 3 - concrete, etc…)

4) Count the number of cells for each class in the image. (Figure 3)

TIP: Number each cell along boundaries where a cell is split between two classes. Number the cells with whichever class covers more of the cell. If it is evenly split between classes, pick one randomly (flip a coin).

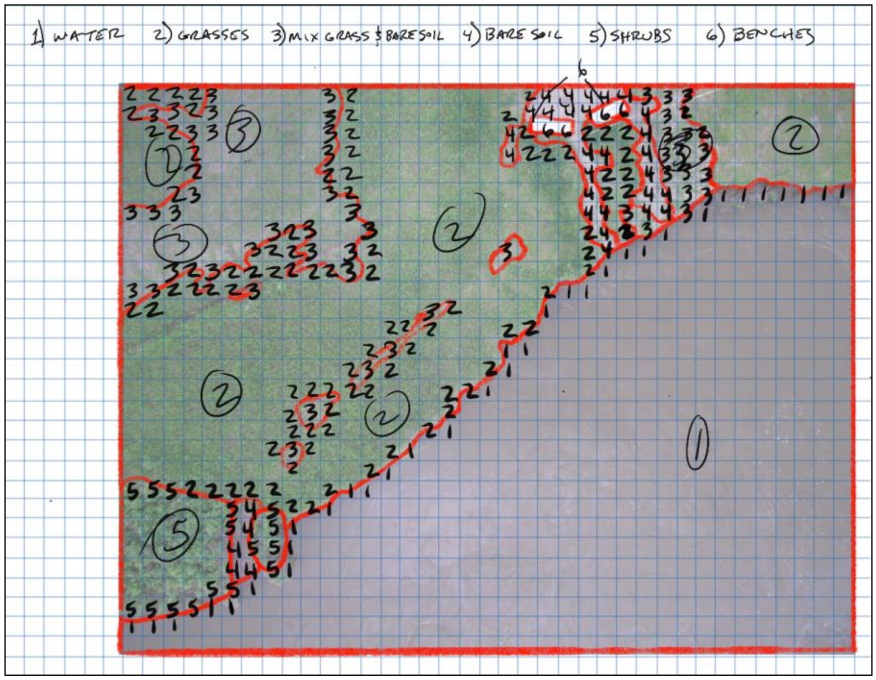


Figure 3

5) List your results and display them in a bar graph (Figure 4)

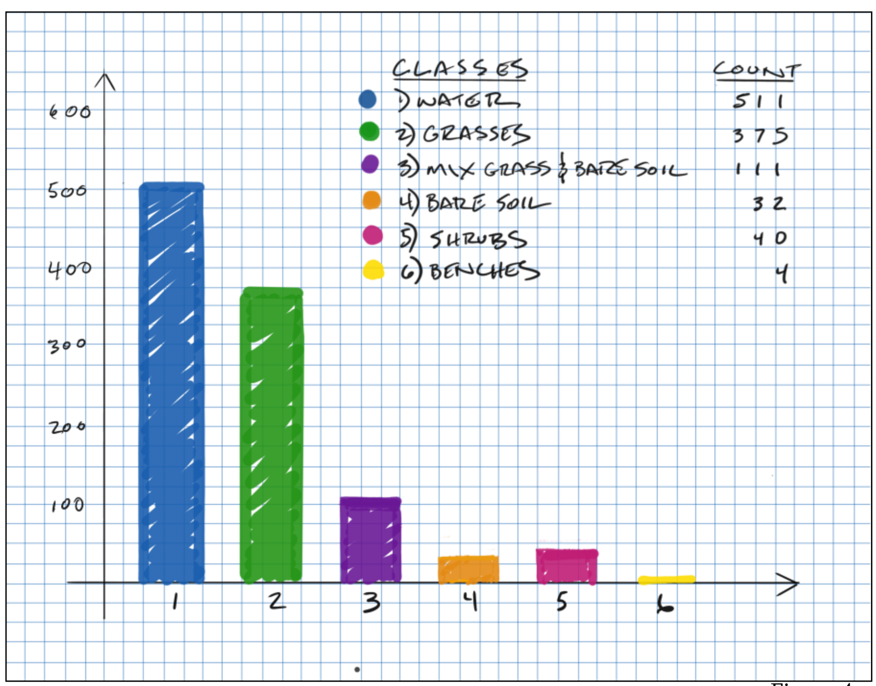


Figure 4

6) You can use a spreadsheet program such as Microsoft Excel, Google Sheets, or Apple Numbers to calculate the percent of total for each class and produce a pie chart of percentages. (Figure 5)

CLASS	CELLS	% OF TOTAL
Water	511	47.6%
Grasses	375	34.9%
Mixed Grasses and Bare Soil	111	10.3%
Bare Soil	32	3.0%
Shrubs	40	3.7%
Benches	4	0.4%
TOTAL CELLS	1073	100%

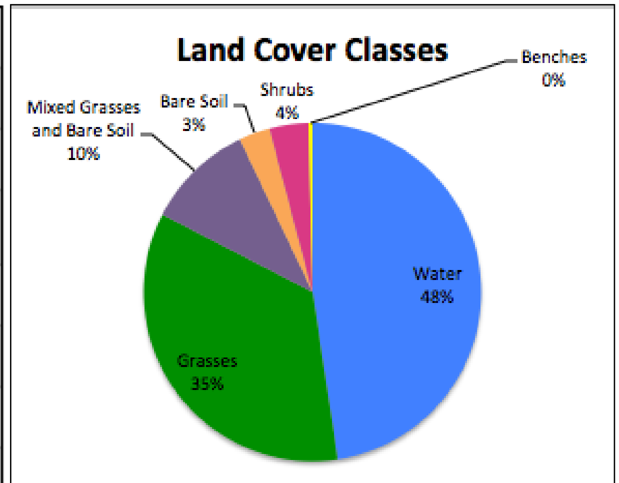


Figure 5

To get the percent for each class use: (CELLS ÷ TOTAL CELLS x 100)

7) Another way to display your data is to color the image according to the class. You can list the

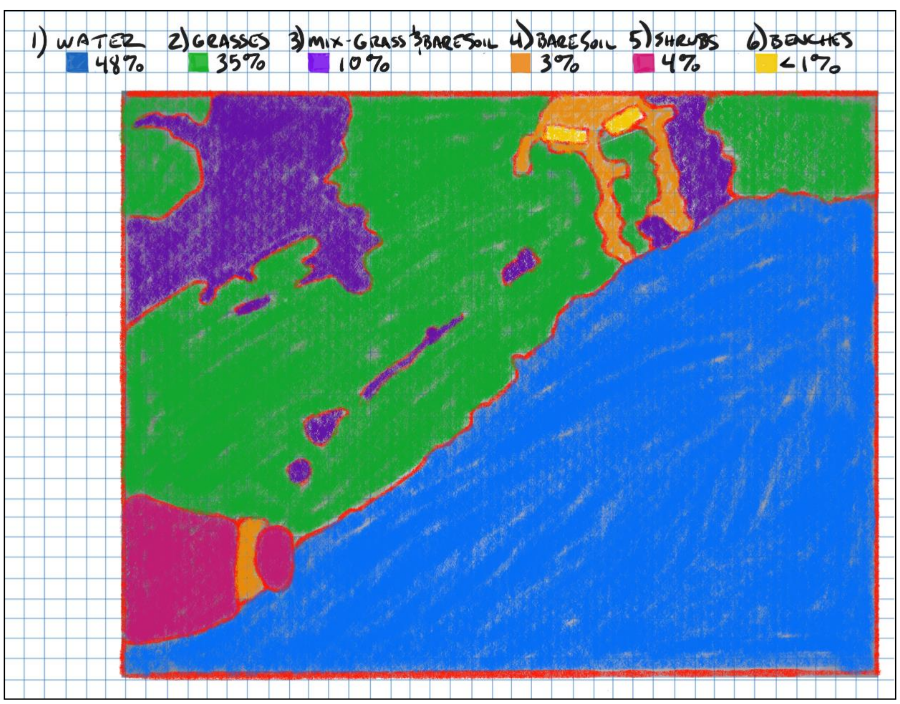


Figure 6

percentages on the key. This is called a ***classified image***. (Figure 6)

Worksheet: Think about it…

1) Map Scale - Cell Size

You may have noticed that even though some features can be drawn as classes on the image, when you counted cells they weren't counted because they only occupied a small percentage of a cell. The cell is classified by whatever occupies the majority of it.

In other words, an object or area in the image can only be counted if it occupies the majority of one or more cells. The size of the cell determines the minimum feature size that is counted.

1. The graph paper used in this example had 4 cells per inch (rows). How would the classified map change if we used graph paper with 5 or 6 cells per inch?

2. Would the accuracy increase or decrease? Could more or fewer features be counted?

3. If we printed the image half as large on the same paper (4 cells per inch) how would that change our results?

4. Can you create a rule that describes the relationship between cell size and feature size

2) Number of Classes

In the example above, we defined six classes. We could have defined fewer or more classes.

1. How does changing the number of classes change our understanding of landcover and land use?

2. How does the number of classes affect the accuracy of the classification process?

3. When would you want to use fewer classes vs more classes?

3) Image Resolution

Digital images are made of ***pixels.*** Pixels are the smallest unit in an image - they are the dots that make up the picture. The number of pixels, and the area each pixel covers in an image determines its ***resolution***. In the image used above (Figure 1), each pixel (dot) covers a few inches on the ground. If you were to zoom in very close, features would start to get fuzzy. In general, for an object to be identifiable in an image, it needs to cover at least 4 pixels.

NASA's LandSat satellite takes images of the Earth from space so that scientists can study the earth. (Figure 7) Each pixel (dot) in the image covers 30 square meters on the ground. If you were to zoom in, a large house would appear as a single pixel of one color. You would not be able to see any features on it, making it difficult to tell what it was.

Figure 7

If you did the same exercise with a Landsat image, the types of classes you could create might be different. The "Benches" class in the example above wouldn't exist, because the benches are much too small to appear in the image.

1. What advantage would a Landsat image have to scientists who are studying Land Cover change, over an aerial image taken with an Aeropod or drone?

2. What advantage would an aerial image from an Aeropod have over a Landsat image?

3. Can you think of a use for each type of image?

NGSS Connections

Performance Expectations:

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ESS3-4 Construct and argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Cross Cutting Concepts:

Patterns

MS: Graphs, charts, and images can be used to identify patterns in data.

MS: Patterns in rates of change and other numerical relationships can provide information about natural systems.

HS: Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

HS: Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments.

HS: Mathematical representations are needed to identify some patterns.

Scale, Proportion, and Quantity

MS: Phenomena that can be observed at one scale may not be observable at another scale

HS: The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

HS: Patterns observable at one scale may not be observable or exist at other scales.

Stability and Change

HS: Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Disciplinary Core Ideas:

MS: Human Impacts:

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS: Human Sustainability

Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Science and Engineering Practices:

Analyzing and Interpreting Data

MS: Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.

MS: Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).

MS: Analyze and interpret data to determine similarities and differences in findings.

Science and Engineering Practices:

Analyzing and Interpreting Data (continued)

HS: Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

HS: Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.

HS: Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.