

Determining Scale & Calculating Area



Purpose

- To apply math skills for the purpose of determining the scale of a map or aerial photo and calculating the area of a specific map section.
- To develop a method for scaling sample site carbon stocks to larger areas of similar vegetation.

Overview

Students will determine a scale for the aerial photo or map they are using to investigate their carbon cycle sample site. The map scale is then used to calculate a given area, such as that of forest in the schoolyard. Vegetated area is required to make an estimate of total aboveground carbon stock within the schoolyard or other desired location, which may be needed for a variety of research questions. Calculating area can be done using several methods; these range from a paper map and grid, [as described here](#), to more complex geographic information system (GIS) and image analysis techniques.

Student Outcomes

Students will be able to:

- Use an aerial photo or map, a tape measure, and math to determine scale.
- Calculate the area of a real world object using map scale and a gridded overlay.
- Develop and implement a method to determine carbon stocks in the vegetated areas of the schoolyard or other desired location.

Questions

Content

- How do you find the distance of an object in real life using an aerial photo?
- How do you determine the scale of an aerial photo?
- How do you calculate area using a grid overlay?
- Why are area calculations important to our study of vegetation carbon stocks? Is the global cycle in balance?

Science Concepts

Grades 5-8

Scientific Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data
- Use mathematics in all aspects of scientific inquiry

Grades 9-12

Scientific Inquiry

- Use technology and mathematics to improve investigations and communications

NGSS

- *Science and Engineering Practices*
 - Analyzing and interpreting data
 - Using mathematics and computational thinking
- *Crosscutting Concepts:*
 - Scale, proportion and quantity

Time/Frequency

60 minutes. Can be completed once OR every year.

Level

Secondary (Middle & High School)

Materials and Tools

- Detailed image of the school property or other desired location showing trees, buildings, fields, etc. – should include a boundary line that defines the area of interest (1 per pair)
- Metric ruler (1 per pair)
- Gridded overlay (1 per pair)
- Wet or Dry erase markers (1 per pair – optional)
- *Student Worksheet* (1 per student)

Prerequisites

- None.

Preparation

1. Locate an image that includes your Carbon Cycle Sample Site and the surrounding area of interest that has enough detail to show where the major vegetation is located. (This may be your schoolyard, a local park, etc.) This



could be an existing paper map, or an image that you save from Google Earth Pro, Google Maps, or elsewhere on the web.

2. Determine and mark the boundary line of your chosen location on the selected map/photo. There are a number of ways to determine this. For instance, you may find a map of the property at the school (check with the main office). Many towns and cities are now providing maps of property boundaries on their official website (for instance, go
3. to the 'map' link at <http://www.onconcord.com/>). For more ideas see the instructions below.
3. Make copies of the map with a boundary line for each student pair that requires area information to answer their research question.
4. Create or use a gridded overlay of the image where each grid-cell is of a known size. (The attached 1cm x 1cm grid can be printed/copied on to transparencies for repeated use.) Make one copy for each student pair.

Example: Calculating forested area using Google Earth Pro

*The Google Earth Pro application can be downloaded for free here: www.google.com/earth/download/gep/agree.html

1. Open Google Earth Pro and fly to your location of choice.
2. Determine the boundary of the area you would like to study through local maps. By comparing the boundary of your area to the Google Earth image, you can draw the boundary directly in Google Earth as an image overlay:
 - a. Select the 'add polygon' button on the top toolbar of Google Earth. Rename the polygon, select a line color that is easy to see, choose outline only, and then click on the image where you want to start the boundary. (DO NOT click OK until you have completed the outline.)
 - b. Each time that you click on the image, a new point will be set to create the polygon. You will close the polygon by making your final click as close as possible to the first point.
 - c. Once you have created the polygon, click and hold the points, fine-tuning the location of each one to better match what you know about the boundary. Points turn green when you 'mouse-over' them, and at that point, you can click and move the point to reshape your polygon.
 - d. Click OK. You can return to this later for editing, by right clicking this object in the 'my places' list in the left sidebar. This boundary polygon can be saved as a googleearth.kml file (file/save/save place as/file.kml).
3. Take a screen shot to print the map with its new boundary line (you must be able to see the vegetation in the printed image).
4. Overlay a grid of known size onto the map. A 1cm x 1cm grid is available below.
5. Use the markers to count and keep track of the grid cells that contain at least 50% forest (or your vegetation type of interest).
6. The area of the forested land can be calculated as: $\text{Forested area} = \# \text{ of grid cells} \times \text{area of each grid cell (m)}$. This will require a conversion from 1cm x 1cm to meters using the photo/map scale as indicated in the section below.

What To Do and How To Do It

ENGAGE

Grouping: Class

Time: 10 Minutes

- As a whole class, review your overall research question. What information have you gained that helps to answer the research question? What information do you still need? Describe to students that they will use a map/aerial photo to determine a map scale that can be used to calculate a given area in the map.

EXPLORE

Grouping: Pairs

Time: 40 Minutes

- Group students into pairs. Give each pair a map, metric ruler, and *Student Worksheet*. Students complete the worksheet, retrieving a gridded overlay and dry erase markers once they reach Part 3 of the *Student Worksheet*.

EXPLAIN

Grouping: Class or Pairs

Time: 10 Minutes

- When students have completed worksheet, guide the students through developing a procedure/ equation that can be used to answer their research question. This can be done as a whole class, or within their student pairs. The specific procedure and equations will vary depending on the research question asked.
 - **Example.** For the research question: 'How much carbon is stored in the forests of my schoolyard?' students would use the same method they used in the worksheet to calculate the total forested area in the schoolyard. They would then develop an equation such as:

$$\text{Carbon Stock of Schoolyard} = \text{Forested Area of School (m}^2\text{)} * \text{Carbon Stock of Forest Sample Site Plot (g/m}^2\text{)}$$

Name:

Date:

Determining Scale & Calculating Area

Part 1: How do you find the distance of an object in real life using an aerial photo?

1. Using the aerial photo provided, measure the length (cm) of an object in the school property (i.e. tennis court side, parking lot length, school building wall). This will be considered “photo distance.” Measure the same length twice (Trial 1, Trial 2), and then average the values. Enter your measurements in Table 1.

Go outside and measure (to the nearest 0.1m) the same object you just measured on the aerial photo, this will be considered “ground distance”. Enter your measurements in line 2 of Table 1.

Table 1	Trial 1	Trial 2	Average
Photo distance of feature 1 (cm)			
Photo distance of feature 1 (cm)			

Convert the average ground distance from meters to centimeters:

_____ cm

2. You can now write these two measurements as a ratio. (Be sure to use the same units!)

Photo distance/Ground distance ratio: _____

3. Measure the length (cm) of a 2nd feature on the aerial photo. Select any feature, as you will not be going back outside to confirm the measurement. Record in Table 2.

Table 2	Trial 1	Trial 2	Average
Photo distance of feature 2 (cm)			

Using the known ratio from above and equation below, calculate the ground distance (cm) of the 2nd feature you measured in the aerial photo. [Solve for X].

$$\text{Example: } \frac{\text{Photo distance}}{\text{Ground distance}} = \frac{\text{Photo distance } 2^{\text{nd}} \text{ feature}}{(X) \text{ ground distance } 2^{\text{nd}} \text{ feature}}$$

Ground distance of feature 2: _____ cm _____ m

Part 2: How do you determine the scale of an aerial photo?

1. Find a feature on the aerial photo that is 1cm in length. Then, use the same equation as above to calculate the ground distance of the 1cm feature.

Ground distance of 1cm feature: _____ cm

2. Compare your results with other groups, by filling in the table on the board. How do everyone's answers compare? What are some reasons that your answers are not identical?

3. What you have just determined is called the photo/map scale. Photo/map scale is written as photo distance: ground distance, for example 1:3000. This means that for every 1cm on the aerial photo is equal to 3000cm on the ground.

Part 3: One method for determining ground area on an aerial photo or map.

1. Retrieve a grid overlay.

What is the size of each grid cell on the overlay? _____ cm x _____ m

Use the photo/map scale to determine the area of a grid cell (m²) on the ground
(remember to convert from cm to m when using your photo scale)

_____ m x _____ m = _____ m²

- Select an object or defined portion of your photo that is greater than the size of one grid cell. You will determine the area of this object.
- Overlay the grid onto the photo. You will notice some of the grid cells are completely contained by the object you have chosen, while others overlap the border. To calculate the object's area, count the number of grid cells, which are at least 50% contained within the object's borders. Do not count grid cells where less than 50% of the cell is within the borders. With these rules, you will see that some area is outside of the boundary is counted, whereas some area within the boundary is not counted. This is a reasonable

approximation of the total area of the object.

- NOTE: The size of and orientation of the grid cells, as well as the individual making the assessment, may influence the final answer, and the calculation will vary accordingly.

Total ground area = Number of grid cells counted * the size of the grid cell in square meters

Tally number of grid cells: _____

Object Area = _____ m²

4. The grid method is just one way of determining area for “on the ground” features. There are several others. Brainstorm additional methods you might use to determine the area of desired objects in your schoolyard, town, watershed, or region.