Lesson 5:
Reading and Interpreting Maps and Aerial Photographs

TEACHER: _______________________

SCHOOL: ________________________

GRADE LEVEL 9-12

**TASKS/COMPETENCIES**

ANR8046.162 Identify and describe topographic map, relief map, aerial photography and infrared photography.

ANR8046.163 Identify specific landmarks on a topographic land map.

ANR8046.164 Reference known landmarks to topographic map and to relief map.

ANR8046.165 Demonstrate ability to read engineer’s scale in determining distance.

ANR8046.166 Use an engineer’s scale and topographic map to determine percentage slope.

ANR8046.167 Interpret various maps for correlation to geographic features.

ANR8046.168 Identify cardinal directions on maps and in the outdoors.

ANR8046.169 Use a compass to orient various locations on a map.

ANR8046.170 Use triangulation to estimate unknown location from one or more known locations.

ANR8046.171 Use a compass and map to conduct a land navigation exercise.

ANR8046.172 Set up and operate a transit level and rod.

ANR8046.173 Read a rod and a level to calculate slope.

ANR8046.174 Use a transit level to lay out level and sloping contour lines on a sloping land.

ANR8046.175 Explain the parts of a field map.

ANR8046.177 Determine land use from aerial photography.

**OBJECTIVES AND GOALS**

- The student will identify two types of maps and explain the major differences between the two types.
- The student will define *prime meridian*, *latitude*, and *longitude*.
- The student will explain how latitudes and longitudes are numbered.
- The student will explain how maps are scaled.
- The student will define *true north*, *direction*, *azimuth*, *magnetic north*, *magnetic pole*, *geographical pole*, and *bearings*.
- The student will define *elevation* and *relief* and explain how they are represented on maps.
- The student will state four uses of topographic maps.
- The student will identify the importance of aerial photographs in map preparation.
- The student will explain how aerial photographs are scaled.
- The student will identify uses of aerial photographs.

**SOL CORRELATIONS**

*Earth Science*

ES.3 (read and interpret maps, globes, models, charts, and imagery)

**EQUIPMENT, SUPPLIES, AND MATERIALS NEEDED**

- United States Geological Survey quadrangle sheets of the local area
- USDA aerial photographs of local area (1:20,000 contact prints
- Pocket stereoscopy
- Masking tape
- Engineer’s scale or ruler with 0.1-inch divisions
ACTIVITIES

Preparation
Lesson approach
- Maps are very important in our daily lives. They are used in the study of history, geography, economics, and many other special study areas. Road maps are perhaps the most familiar to us. But with a little knowledge and training, we should be able to use topographic maps and aerial photographs just as effectively.
- To use maps efficiently for locating and describing physical and topographical elements of the terrain, a basic knowledge of map features, map symbology, and principles of interpretation is needed.
- Aerial photographs are used to construct topographic maps and to keep the map information up-to-date. The best conditions for evaluating and interpreting terrain will be obtained if the interpreter has both a good topographic map and recent aerial photographs.
- Aerial photographs allow the user to see, with a “bird’s-eye-view,” the lay of the land and physical features of the earth clearly. They can be used to supplement and clarify topographic maps.
- A person can become quite familiar with a particular area of land and never actually “see” its features.

General situation
- Land is often bought and sold without reference to its actual location on maps or aerial photographs.
- Boundary lines, roads, fences, and rights-of-way are often mislocated or even “lost,” which may result in court cases and ill feelings between neighbors.
- Forest products are sold with written contracts; however, the description of the land from which it is to be removed is given verbally, and its exact location may be in error.
- The proper use of maps and aerial photographs can increase the efficiency and ability of land appraisers, contractors, and engineers.
- There are many job opportunities available in the wood-using industry for people skilled in the interpretation and proper use of maps and aerial photographs.

Local situation
- Determine the following information from students:
  - How many students live on a farm or own land for which they do not have a map?
  - How would they locate their land or a particular parcel of land with only a verbal (legal) description?
  - How was the acreage on their farm estimated?
  - How would they go about locating the best place for a main road or a new power line right-of-way to a specific location on the farm?
- If the majority of students in the class do not live on a farm, the material should be modified to reflect suburban or urban uses of maps and aerial photographs.

Application
- Have each student study a U.S. Geological Survey quadrangle sheet of the local area. Point out the map symbols, legend information, and the representations of elevation and relief.
- Select a tract of land (at least 50 acres in size) in the local area that can be located on the topographic map from a legal description.
- Have students study the terrain of the tract carefully on the map; measure the distance and direction of the boundary lines or selected roads within the tract; then determine the acreage of the tract, using the dot-grid method.
- Take students on a field trip to the selected tract. Have them use the topographic map to navigate to the property and study the map representation of elevation and relief, comparing them to their actual appearance. Photographs of objects and areas of the tract can be taken during the field trip and compared to the map symbols.
- Locate the same tract on aerial photographs.
Presentation: Maps and Aerial Photographs

Understanding maps
A map is a graphic representation of the earth’s surface or part of it, drawn to scale on a plane, with both human-constructed and natural features depicted by symbols, lines, and colors.

Types of maps
- A planimetric map shows only the horizontal (flat) position of constructed and natural features (e.g., highway map).
- A topographic map depicts both the horizontal and vertical (relief) positions of constructed and natural features. The distinguishing characteristic of a topographic map is the portrayal of the shape and elevation of the terrain with lines, colors, and symbols.

Map coordinates
Two-dimensional geographic coordinates are based on distances from an east-west line running through the equator and from a north-south line running through Greenwich, England. The line from the North Pole to the South Pole running through Greenwich is called the prime meridian.

Reference Lines for Geographic Coordinate Systems
- Latitude—the distance of a point north or south of the equator is known as its latitude, and the rings around the earth parallel to the equator are called the parallels of latitude.

Position Location with Graphic Coordinates
- Longitude—the distance of a point east or west of the prime meridian is known as its longitude, and the rings around the globe at right angles to the equator passing through the poles are known as meridians of longitude.
Angular measure with geographic coordinates

The unit of angular measure is the degree. Each circle is divided into 360 degrees, and each degree is 60 minutes. Starting at the equator, parallels of latitude are numbered from 0 to 90 north and 0 to 90 south. Direction north or south must always be given, since latitude can have the same numerical number on either side of the equator. The poles are at 90 north and south latitude.

Longitude lines are numbered 0 to 180 east and west of the prime meridian. The line directly opposite the prime meridian may have a value of 180 east and 180 west.

At any point on the earth, the ground distance covered by 1 degree of latitude is approximately 69 statute miles. The ground distance covered by 1 degree of longitude is approximately 69 miles at the equator, but decreases as one moves north or south to the poles until it becomes zero.

Map scales, directions, and symbols

Map scales

The scales printed on a map permit the determination of ground distance. To bring a map down to a useful size, everything on it is reduced in size at a uniform rate. The amount that objects have been reduced is indicated by the scale of the map.

- **Representative fraction (RF)**
  The scale of a map expresses the ratio of the horizontal distance on the map to the corresponding horizontal distance on the ground. The RF expresses this relationship as a fraction or ratio, for example, 1:24,000 or 1/24,000. The numerator, always written as 1, represents the map distance; the denominator, a larger number, represents ground distance. The RF is independent of any unit of measure and is written as:

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  RF = \frac{\text{Map distance}}{\text{Ground distance}}
  \]

  The ground distance between two points on a map is determined by measuring the distance between them on the map and multiplying the map distance by the denominator of the RF.

- **Graphic scales**
  A graphic scale is a ruler printed on the map from which distances on the map may be measured. The straight line ground distance between two map points is determined by measuring the map distance with a ruler or a pair of dividers, then comparing this distance directly with the graphic scale.

Direction and azimuth

The direction of any line is the horizontal angle that it makes with the standard direction. The most important instrument for direction determination is the magnetic compass.

- **Magnetic vs. true direction**
  The point of the compass needle marked north points to the north magnetic pole rather than toward the north geographical pole (true north). This direction is called magnetic north. The angle formed between magnetic north and true north is called magnetic declination.

- **Azimuth**
  An azimuth is defined as a horizontal angle measured in a clockwise direction from a base line. Azimuths have values from 0 to 360 degrees.

- **Bearings**
  Bearings are horizontal angles referenced to one of the quadrants of the compass, i.e., NE, SW, SE, NW. Bearings are measured clockwise and counter-clockwise from north or south to east or west.

Color codes for map features

Symbols depicting natural and constructed map features are usually printed in different colors to provide a more natural appearance and color. Each color represents a class of features. The color codes are as follows:

- **Black**—the majority of cultural and human-constructed features
- **Blue**—water features such as lakes, rivers, and swamps
- **Green**—vegetation such as woods, vineyards, and orchards
- **Brown**—the shape and elevation of the topography
- **Red**—boundary lines, large highways, and special features
- **Occasional other colors**—special information indicated in the legend
**Elevation and relief**

**Elevation**
The height of land surfaces in feet above sea level is called elevation.

**Relief**
Relief is the variation in elevation of the earth’s surface. Relief occurs in forms of hills, valleys, ridges, and the like.

**Representations of elevation and relief**
The method most commonly used for representing elevation and relief is that of contouring. Other methods used include the color-layer system. The color-layer system of color shading makes use of special arrangement of colors; each color represents a certain interval of elevation. The color scale for the elevations is shown in the map legend.

**Contour lines**
A contour line is an imaginary line on the ground connecting points of the same elevation. Contour lines indicate a vertical distance above or below sea level. The vertical distance between adjacent contour lines is known as the **contour interval**, and the amount of the contour interval is given in the marginal information. On most maps the contour lines are printed in brown. Starting at the lowest elevation, every fifth contour line is heavier and darker than intermediate contours and is known as an index contour. Along each index contour the line is broken at some place and its elevation given. The contour lines falling between index contours are called **intermediate contours**. They are drawn with a thinner line than index contours and usually do not have the elevation given.

The spacing of the contour lines shows the relief. Contour lines evenly spaced and wide apart indicate a uniform gentle slope. Contour lines evenly spaced and close together indicate a uniform steep slope. The closer the contour lines are together, the steeper the slope.
Uses of topographic maps
Topographic maps are used for area measurement, road planning, agricultural planning, and recreation development.

Fundamentals of aerial photographs
Aerial photographs are photographs taken from aircraft. Through measurement of aerial photographs, it is possible to construct accurate maps containing a great deal of information about land forms, vegetation, and cultural features on the surface of the earth.

Most aerial photographs are vertical photographs and are taken with the camera axis held as nearly as possible in a vertical direction. These are used for preparing planimetric and topographic maps, for land-use surveys, and for forest management and logging surveys.

- Information appearing on aerial photographs
  - Agency responsible for the photograph is listed on the back.
  - An alphabetic code for the county, a flight line number, and the photograph number appear in the upper right hand corner.
  - Date of photography appears in the upper left hand corner.
  - Time of photography may appear to the right of the date on the first and last photograph of a continuous strip.
  - Fiducial marks (half-arrows or small crosses) appear either in the four corners or midway along the border of the print. The intersection of lines connecting opposite fiducial marks locates the optical center of the photograph, known as the principal point.
  - Scale of the photograph may appear on the face or stamped on the back of the photograph.

- Photograph scale
  - Photo scale
    The vertical photograph represents a true record of angles, but horizontal distances are subject to wide variations because of changes in ground elevation and flight altitude. The scale is generally stated in terms of the representative fraction (RF), just as on maps, and is independent of the units of measure.

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  RF = \frac{\text{Photo distance between two points}}{\text{Ground distance between same two points}}
  \]

- Area determination
  The area on a photograph (or map) is determined as the square of the denominator of the RF. For example, given an RF of 1:15,840 means that 1 inch equals 15,840 inches, or 1 inch equals 1320 feet, or 1 inch equals 20 chains (66 feet per chain). Therefore, 1 square inch on the photograph equals 400 square chains, or 40 acres.

- Compass bearings
  Few flight lines are oriented in exact cardinal directions (N, S, E, or W); therefore, a reference line of known direction must be established before bearings to various objects can be determined.

An aerial photograph is not a map. The single aerial photograph is not a map because of image displacements due to topography and photographic tilt. The photo scale is only constant on the datum plane. An accurate map cannot be constructed or traced directly from photographs unless the ground being mapped is perfectly level and the photographs were taken with no appreciable tilt.
• **Uses of aerial photographs**

The advantages of aerial photography lie in the accuracy and speed for obtaining information of the physical features of relatively large, often inaccessible areas. Aerial photography can be more economical than other methods of survey.

− **Area measurement**

There are several methods of estimating size of irregular areas. Two of the more common methods include **planimeters** and **grids**.

• **Planimeters**

The planimeter is a mechanical device consisting of several small wheels, a numerical dial, and a tracing area. The boundary of the area is traced with the point on the tracing arm in a clockwise direction, and area in square units can be read on the instrument dial. Planimeters yield accurate measurements if carefully used.

• **Grids**

Grids consist of intersecting lines forming rectangles or squares, which are drafted onto the map or photograph or simply superimposed by means of a transparent overlay. Each grid or square is assigned an area value according to the scale of the photograph. For instance, if a grid contains 1,000 squares and 450 of them fall in a particular area, the size is thus 450 times the acreage or the area of an individual square. A modification of the grid called the *dot grid* consists of systematically placed dots on a transparent plastic overlay. The dot grid is placed over the photograph or map and the number of dots falling within the effective area are counted. The acreage per dot is multiplied by the number of dots to obtain the total acreage. These overlays are available from suppliers of forestry materials.

**ADDITIONAL ACTIVITIES**

• Display examples of planimetric and topographical maps, and discuss the purpose and uses of each type.

• Determine if there are students in the class who live on farmland for which no map exists. Discuss the following questions for such cases:
  − How could this land be located from a verbal or legal description?
  − How can the acreage of the farm be estimated?
  − What methods can be used to locate the best place for a main road or new power line right-of-way to a specific location on such a farm?

• Present examples of cases in which maps were used or could have been used to prevent misunderstandings or financial loss.

• Have students practice locating assigned locations on topographic maps.

• Display examples of aerial photographs and compare them with corresponding maps. Have students identify objects in aerial photographs.

**SUGGESTIONS FOR STUDENT EVALUATION**

Interpretation of the map symbols, legend information, and the representations of elevation and relief on a U.S. Geological Survey map of the local area may take the form of written or oral tests.

**SUGGESTED RESOURCES**

- *Elementary Topography and Map Reading*. Samuel L. Greitzer
- *Forestry Handbook*. Society of American Foresters
- *Manual of Photographic Interpretation*. American Society of Photogrammetry
- *Map Reading and Topographical Sketching*. Edwin R. Stuart
- *Photogrammetry and Photo-Interpretation*. Stephen H. Spurr
- [http://www.lib.berkeley.edu/EART/digital/legend.html](http://www.lib.berkeley.edu/EART/digital/legend.html)