

# Georeferencing Using Paper Maps

## Workshop Guide

On-line Resources, while helpful, cannot be used to georeference every locality. Thus, basic knowledge of paper maps is needed by all georeferencers.

### Pros of Paper Maps

- Necessary for certain localities, such as distances by road and topographic features, especially when GIS layers are not readily available
- Extents more readily obtained
- Old paper maps may be the only option for obtaining coordinates for historic localities

### Cons of Paper Maps

- Time-consuming
- Good quality paper maps may be hard to find
- Map printing errors

### The Anatomy of a Map

**Map Scale:** Map scale is usually recorded as a ratio, such as 1:100,000, or a fraction, such as 1/100:000. For this example, one unit on the map is equal to 100,000 units on the ground. Generally, larger scale maps, such as 1:24,000, show more detail and are better for determining extents and offsets of short distances. Smaller scale maps, such as 1:1 million, are better for determining coordinates of large geographical areas, such as mountain ranges and rivers, or for determining offsets of great distances.

**Grid:** The map grid shows the placement of the parallels and meridians on your map and is used to determine latitude and longitude. The latitude is marked on the east and west sides of the grid, and the longitude is marked on the north and south. The smaller the scale of your map, the greater the distance will be between your grid lines, which can affect the quality of your georeferencing. Some maps have no grid. Such maps may be solely used for determining extent.

**Datum:** In the best situations, the datum will be recorded on the map, usually at the bottom. If no datum is recorded but the map states which reference ellipsoid was used, then one can sometimes make assumptions about the datum based on the reference ellipsoid and the region, using the document found at <http://earth-info.nga.mil/GandG/publications/8350.2/g84fin.pdf>. Some maps will have neither the reference ellipsoid nor datum labeled. While such maps can still be used, be aware that an extra 0.6 mile will be added to your error due to datum uncertainty.

Of course, the maps available to you may be limited. Ideally, your map will have a datum recorded and you will have your choice of both small and large scale maps. However, as this is not usually the case, you will need to make decisions on whether or not to use lower-quality paper maps based on time constraints, map availability, and the types of localities needing coordinates.

## **I. Determining Coordinates from Paper Maps with a Ruler:**

The most basic method to determine coordinates from paper maps is by using two rulers. The following instructions are for a 1:50,000 map with a grid whose tick marks are placed 5 minutes apart, but it can be adapted for any map scale.

1. First calculate how many minutes are in each millimeter using the grid as labeled on the side of each map. Since the grid is marked at every 5 minutes, and if there are 185 millimeters between each tick mark, then you know that there are 0.027027 minutes per millimeter (5 minutes/185 millimeters). Note that the numbers will be different for latitude and longitude, and occasionally, for different maps of the same series.
2. Next, locate the point on the map that you need to georeference. Using your ruler, measure the distance, in millimeters, from your point to the nearest tick mark. Note whether latitude and longitude increase or decrease as you move from a tick mark to the point you want to georeference. This will tell you whether you need to add or subtract your converted degrees in the next step. Also record the degrees and minutes of the nearest tick mark from which you are referencing. Do this for both the latitude and longitude.
3. Multiply the number of minutes per millimeter by your value from number 2. This gives you the difference, in minutes, of your georeferenced point from your reference tick mark. Add (or subtract) this value to the minutes as recorded of your tick mark, depending on which is appropriate. For example, if the point you are georeferencing is 95.5 millimeters from the 9°50' tick mark, then 95.5 millimeters x 0.027027 minutes per millimeter is 2.58 minutes. 2.58 minutes should then be added to the 50', so your end coordinate is 9°52.58'. Check your map to make sure that this value makes sense.

There are other tools that can make georeferencing using paper maps easier, such as rulers designed specifically for certain map scales that will show the minutes and seconds directly on the ruler, and electronic measuring wheels that can be set for different map scales and will show the distance traveled on its display. Coordinate precision is based on how precisely you can measure with whatever tool you are using. In our case, the smallest unit of measurement on the ruler is 1mm. Using the above conversion, you can convert 1 mm to degrees, which will give you your coordinate precision.

## **II. Determining Coordinates Using the Error Calculator**

The error calculator has a function that will give you the coordinates of your endpoint if you have coordinates for a starting point and an offset. Essentially, that is what you are doing when determining coordinates on a paper map based on the known "starting" coordinates of the grid lines. For this method, you must use the calculator twice: once to obtain your coordinates, and again to calculate your error.

1. Choose the corner of your map that will allow you to add degrees to your starting coordinates. In the NW hemisphere, this would be the SE corner of the map. Note these coordinates.
2. Identify the point on the map you are trying to georeference. Measure the distance north of your latitude grid line to this point and note this distance in mm. Measure the distance west of your longitude grid line and note the distance.

3. In the error calculator under "Calculation Type" choose "Coordinates and error-enter Lat/Long for the named place or starting point" from the drop down menu. Under Locality Type, select "Distance along orthogonal directions." Select your coordinate source and system.
4. Enter the coordinates of your SE corner into the Latitude and Longitude fields. Ignore the Datum and Coordinates Precision fields. These are related to calculating error.
5. At the bottom of the calculator, there is a scale converter which will convert your map measurements from the grid lines into offset distances. Enter the converted distance into the offset fields. Ignore the Extent, Distance Units and Distance Precision fields, which are related to calculating error. Hit the Calculate button and your end point coordinates will appear in blue.
  - a. For Example: Starting at the bottom left corner of a 1:50,000 map, you measured 35 mm north from the latitude grid line and 171 mm west from the longitude grid line.
  - b. The calculator converts these measurements to 1.75 km and 8.55 km respectively. These are your North and West orthogonal offsets.
  - c. Enter these offsets into the calculator accordingly and make sure the cardinal directions are chosen appropriately. Calculate and viola!
6. At this point you will use the calculator again to determine your error. Change the Calculation Type to "Error only" and choose the Locality Type that best fits your locality description. At this point enter the coordinates obtained from step 5 into the Latitude and Longitude fields. Enter the map data, your calculated coordinate precision, offset data and distance precision (if applicable) and extent.