

EXERCISE

Georeferencing Historical Imagery in ArcGIS Pro



Introduction

Sometimes imagery, especially historic imagery, is not georeferenced (i.e. does not have a coordinate system that allows the image to appear in the correct location on the earth). There are numerous ways you can do this in this exercise we will use ArcGIS Pro. Pro is best used when you have a small number of images. For this exercise we will use an image from the Cibola National Forest taken in 1958. It is helpful to have a rough sense of where the imagery comes from so, we will use the web to help orient ourselves.

Objectives

- Learn how to georeference an image to a project area

Required Data

- **052717_0040.jpg**– Historic Imagery to georeference (More can be found using Current NHAP CONUS Scanned Imagery Coverage webtool)
- **Cibola_NF.bkmx**- bookmark of project area

Prerequisites

- Install Esri ArcGIS Pro on computer
- Have Spatial Analyst and/or Image Analyst Extension
- **Add Image Server to Pro – this add-in gives you quick access to large amounts of FS imagery.** It can be easily added to ArcGIS Pro.



USDA Non-Discrimination Statement

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotope, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at [How to File a Program Discrimination Complaint](#) and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.



Table of Contents

Part 1: Create Project and Load Data	4
Part 2: Image Positioning	5

Part 1: Create Project and Load Data

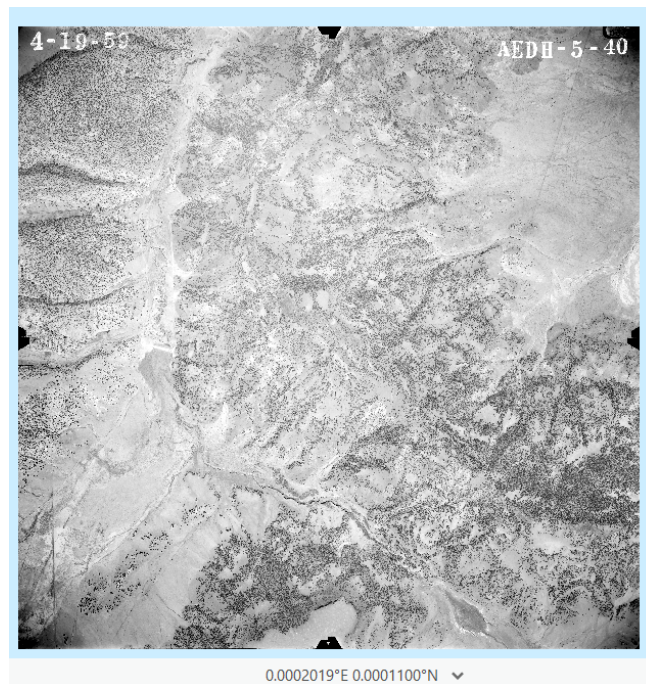
Quickly set up your project in ArcPro and load all necessary data for this exercise.

A. Create Pro Project

1. **Open** ArcGIS Pro
2. **Select Map** under Blank Templates
 - i. Label the project RasterFunctions_Exercises
 - ii. Choose your project location. You can create a new folder if you want.
 - iii. Click **OK**

Part 2: Add course data

1. Click the **Add Data** button from the **Map** Tab in the **Layer** Group and navigate to where you placed the course material.
2. Select **052717_0040.jpg** and click **OK**.
3. From the Contents pane, right click on the .jpg and **Zoom to Layer**
 - i. Unreferenced images are added at the intersection of the Equator and the Greenwich Meridian. This is where ALL unreferenced data is displayed in Arc.

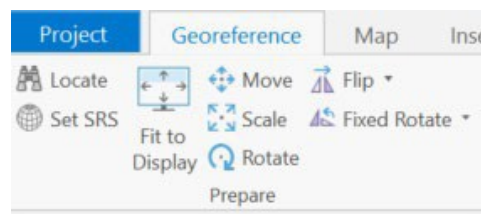


Part 3: Image Positioning

All geospatial data and imagery should have a defined coordinate system or spatial reference. This should be the first thing you do when georeferencing an image.

A. Set Coordinate System

1. In the **Contents** pane **highlight** the historical imagery
2. Click on the **Imagery** tab, in the **Alignment** group, click **Georeference**. A whole new tab is displayed.
3. On the **Georeference** tab, in **Prepare** group, select **Set SRS**



4. Select the **Coordinate Systems** tab, drop down **Layers** and select WGS 1984 Web Mercator
 - i. Your imagery is now correctly projected, and any tie points added will be done in this coordinate system. We still need to get it positioned in the right spot before we can properly georeference it.
5. Click **ok**
6. Navigate to the Georeferencing_Exercise folder and select the Cibola_NF.bkmx click ok to add the bookmark.
7. Click on **Bookmarks** then click the **Cibola_NF** bookmark to navigate to part of the Cibola National Forest near Albuquerque, NM.
8. Select the **Georeference** tab, in **Prepare** group, click **Fit to Display**. Click **Save** in the georeferencing pane to update the location and coordinate system data of your image.
9. In the **Map** tab, **Layer** Group, select **Basemap** and then click on **Imagery** (without labels)
 - i. Examine imagery using the Swipe in the Appearance tab, Effects group. We can see a stream running north to south and a road in the unforested area in the upper right. Identify these features in both the historic imagery and the basemap.
10. Next, we will review the current position of the image, its scale, and adjust it to the best fit before we add control points. You will need to use the swipe tool, transparency and many of the tools under the Prepare group on the Georeferencing tab.
11. Use the **Move**, **Scale**, and **Rotate to Display** tools loosely line up the aerial image. This will not be perfect but use larger landscape features to help. These tools are designed to help you adjust and refine the image location. Transparency can also be applied to the image to help in positioning. Click **Save** after you've adjusted it

Note: The process of aligning the image with a reference layer is also called registration. As you move, scale, and rotate, you might notice the location registration is improving, but it is impossible to achieve the same level of registration across the whole image. As you fix registration in one area it modifies registration in another area. You'll use control points and a transformation method to gain a better overall registration across the image.

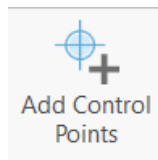
Trick: To exit any of these tools click the Explore feature found in the Map tab, Navigate group, Explore.

B. Applying Control Points

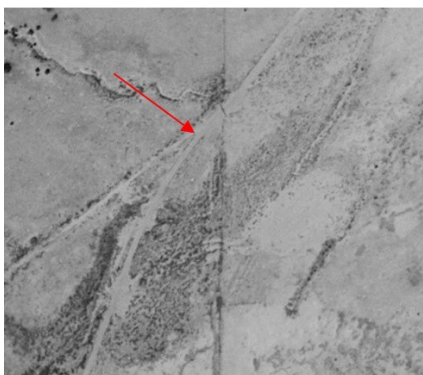
When applying control points, you want to use locations that haven't changed and are not heavily affected by the angle of a sensor. For example, building corners or tops of large trees may appear to "lean" in different directions depending on the angle the image was taken. This is called parallax and occurs when imagery is off nadir. So, choose features on the ground like roads, intersections or large identifiable landscape features like rocky outcrops or easily identifiable short tree patches.

Depending on the type of transformation you are doing will determine how many control points you are required to use. When Auto Apply is active it will automatically select the transformation for the source layer and update the display as you add or remove points. You can use as many control points as you feel necessary. A general rule of thumb is to have one in each corner and one near the center.

1. Make sure **Auto Apply** is on in the Geoprocessing tab, Adjust group
2. Select **Add Control Points** (Georeference tab, Adjust group, Add Control Points)



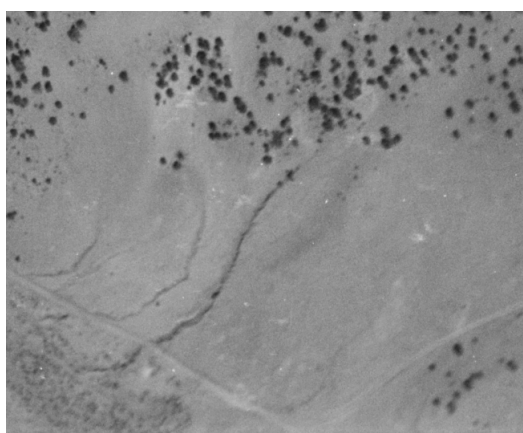
3. In the lower left corner of the aerial imagery find the intersection of two roads. Click the intersection to drop the From Point
4. Turn Off the imagery in your TOC



5. In the base imagery you'll notice a new paved road in this area, but you can still make out the intersection of these older dirt roads. Find the same spot on the base imagery and place your target point.



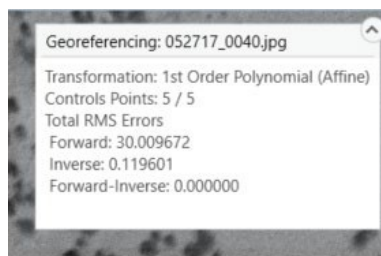
6. Place the second point in the lower right corner. Find a bend in the road at the edge of the aerial imagery and Follow the same process as above to place a control point on the historical imagery and then the basemap.



7. **Place at least three** other control points, try to put one in each corner and one in the center of the image.

Note: As you add additional control points, the source raster is adjusted, and a transformation is applied. Depending on the number of control points added you can choose between several types of transformations. These include polynomial, spline, adjust, projective and similarity transformations, that affect the amount of shifting, rotating and warping applied to the raster (ERSI).

8. Open the Georeferencing box that is located on you map in the upper right-hand corner.



9. In the Georeferencing box there a total RMS Error which is a sum of all the residuals and measures how accurately the chosen transformation equation can fit all the different points to their specified location (ESRI). The RMS error reported

with the transformation refers to the ability to the current mathematical model to fit the existing control points but doesn't report the accuracy of the image.

10. Open the control point table (Georeference tab, Review section, Control Point Table.) The Control Point Table individual residual values associated with each control point are listed. For each control point, the residual is the difference between where the from point displays in the map, as opposed to the actual location that was specified. The lower the residual the better. The current transformation method applied is 1st Order Polynomial (Affine).

i. The first-order polynomial transformation is commonly used to georeference an image. Use a first-order or affine transformation to shift, scale, and rotate a raster dataset. This transformation method ensures that straight lines on the raster dataset will remain mapped as straight lines in the output raster dataset. Squares and rectangles on the raster dataset may be changed to parallelograms of arbitrary scaling and angle orientation ([ERSI](#)).

	Link	Source X	Source Y	X Map	Y Map	Residual X	Residual Y	Residual
<input checked="" type="checkbox"/>	1	692.767283	-690.092935	458.420.199717	4,469.317.934976	167.081216	-225.632441	280.759918
<input checked="" type="checkbox"/>	2	166.079152	-697.871995	448.795.922546	4,469.523.439500	-66.284189	117.327956	134.756977
<input checked="" type="checkbox"/>	3	643.200916	-343.640549	457.535.026252	4,475.775.763160	-46.158080	144.030221	151.245737
<input checked="" type="checkbox"/>	4	49.741727	-134.288220	447.241.321127	4,479.170.464608	108.496590	-139.384775	176.634157
<input checked="" type="checkbox"/>	5	493.135144	-415.309349	454.699.980856	4,474.475.735453	-163.135537	103.659039	193.283211

11. Click the drop-down arrow to the right of **1st Order Polynomial (Affine)**. There are various transformation types available. Depending on how many control points you have will determine available transformations.

12. Choose between the available transformations and select the one that fits best. In this case the Projective transformation had the lowest RMS, but this will be different depending on your control points.

13. Review your image then on the Georeference tab, in Save group, click **Save**

i. Georeferencing modifies the shape of the original pixels and performs a process of resampling of the image. Saving the image updates and maintains its georeferencing information in an associated auxiliary file. The auxiliary file contains transformation parameters for the image (ESRI).

Congratulations! You have successfully completed this exercise. You now know the basics of georeferencing in ArcPro. Hopefully you also had a chance to build upon your image interpretation skills.