



Georeferencing the MacConnell Aerial Photo Collection

University of Massachusetts Amherst

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<https://storymaps.arcgis.com/stories/a20062936eb84014ba457b87a949302c>

Intro

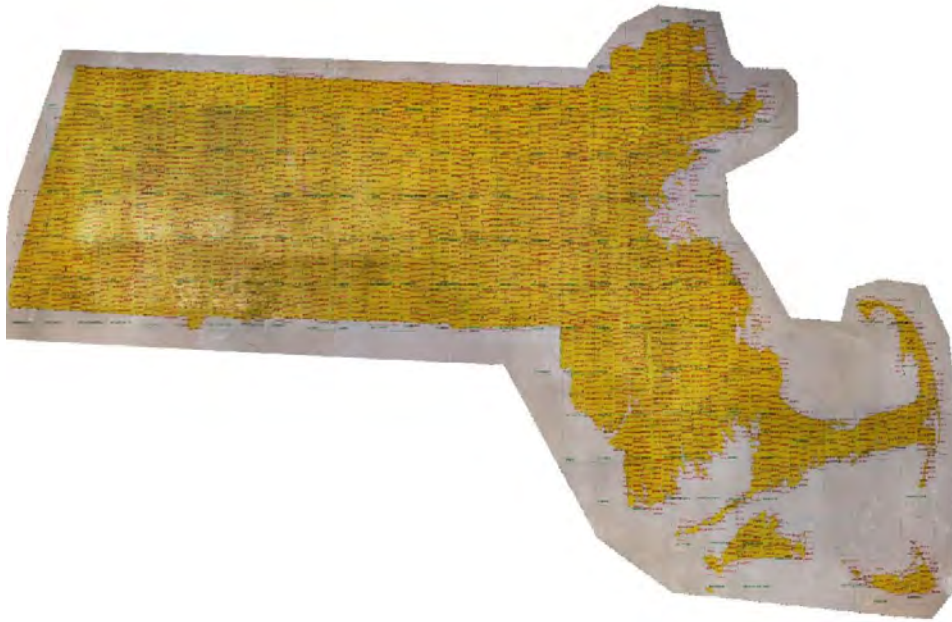
In the 1950s, Professor William P. MacConnell from the University of Massachusetts Forestry Department began working with his students to map the land cover in Massachusetts via the state's earliest aerial photography program. These individual photographs are now part of the Special Collections and University Archives at the University of Massachusetts Amherst Libraries, and although they have been digitized and made available online, they have not yet been georeferenced.

In Spring 2021, our team (Alex and Matthew) began manually georeferencing the photos in ArcMap 10.8 software onto USGS 2019 color orthoimagery of Massachusetts available from MassGIS. Ideal ground control points include building corners, intersections, and any other distinctive features that have not resulted in much change between the historic and contemporary aerial photos. Some challenges we have faced include varying angles in which the photos were taken, cliffs that offset height in parts of the photo, or photos with a heavily forested area that makes georeferencing difficult to pinpoint ground control points.

The goal of the project is to georeference the approximately 4,800 individual photos from the 1951-52 series, which spans the entire state of Massachusetts, in order to make them available to the general public as downloadable GeoTIFFs. This result will allow anyone to access the photos and use them to analyze land-use changes in Massachusetts spanning the last 70 years. Manual georeferencing has come with its own challenges when encountering heavily forested aerial photos or aerial photos dominated by mostly urban areas. We find that future research into the potential automation of the georeferencing process would help alleviate the challenges associated with manual georeferencing.

Photo Organization

The aerial photos originally existed only in physical form. The project started when the Libraries' Special Collections & University Archives individually scanned and uploaded them to an [online collection](#). The photos came with an index map of Massachusetts that showed the general location of each photo, along with its unique photo ID.



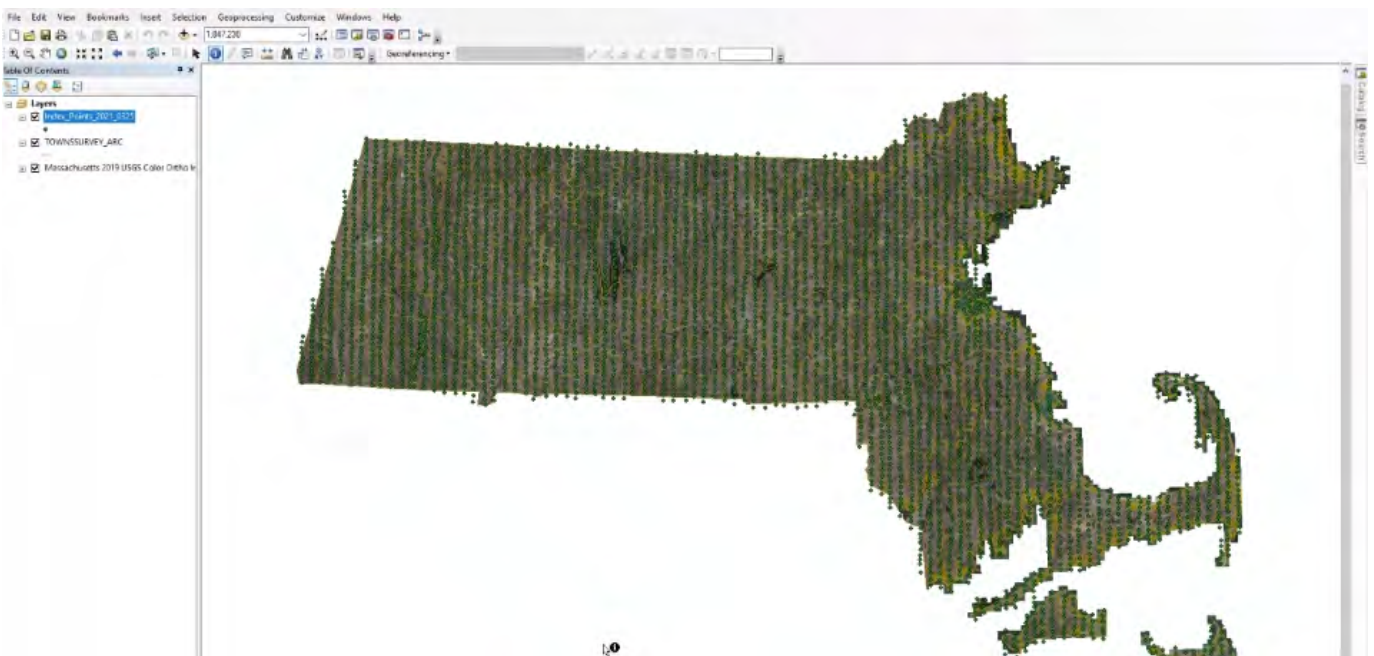
The MacConnell Aerial Photo Flight Index (1951 - 1952)

"Center point" of each photo:

The index points represent the "center point" of each MacConnell photo.

After digitizing the points on the index map, we were able to query the individual points to identify the following:

- Map IDs
- X and Y coordinates for the center of the photo



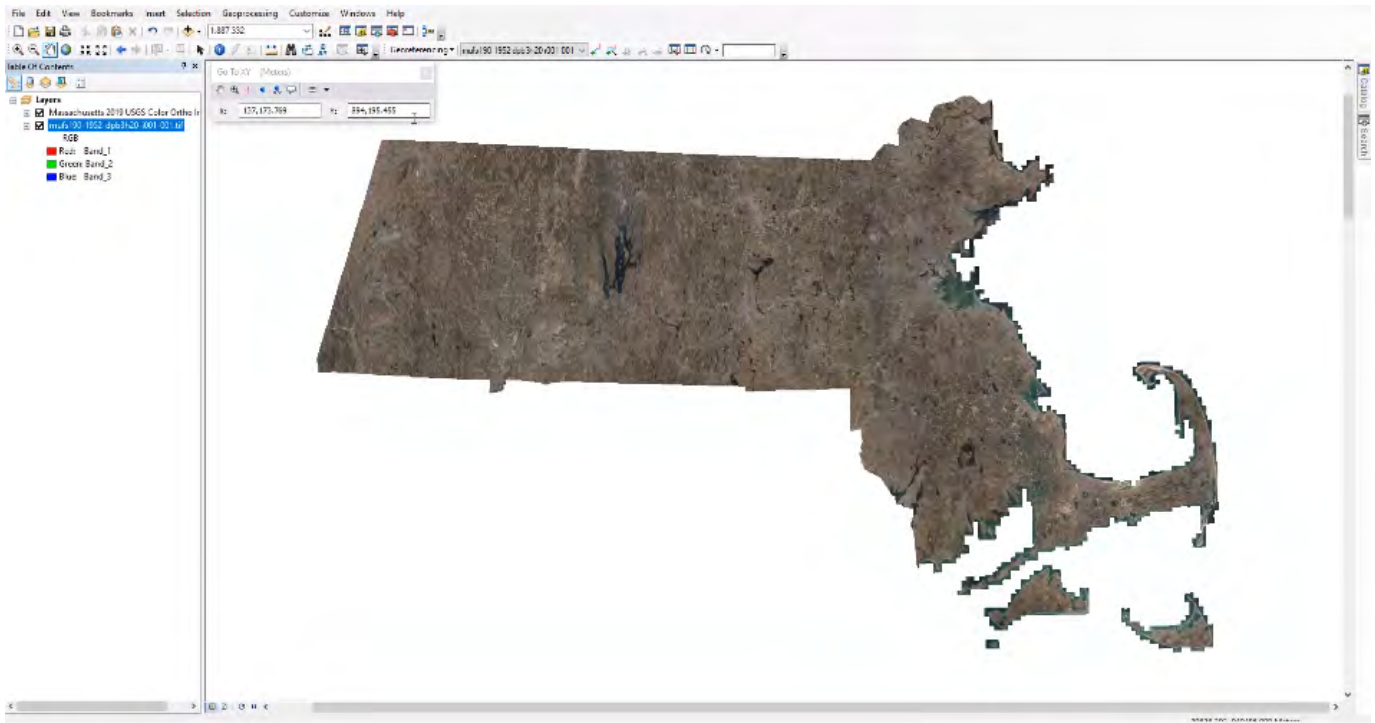
These coordinates were organized into an extensive index, so the general location of the photos could be identified via a single coordinate position. Once the georeferencing process started, we also began cataloging which photos had been georeferenced, as well as writing notes about them, as well as writing notes about them.

	A	B	G	H	I	J	K	L	M	N	O	P	Q	R	
1	map_id	Town	Photo Filename	Coord X	Coord Y	Coord Notes	has match	no photo	no coord	Georef By	Date	Annotation	GCPs	Polynomial	f
2	CNI-5H-24	Agawam	mufs190-1952-cni5h24-i001-001.tif	106119.2531	865433.2892			1		AH	5/6/21	None	15	2nd	
3	CNI-5H-25	Agawam	mufs190-1952-cni5h25-i001-001.tif	105992.2528	867253.6262			1		AH	5/6/21	Whole image	16	2nd	
4	CNI-5H-26	Agawam	mufs190-1952-cni5h26-i001-001.tif	106055.753	868798.7959			1		AH	5/6/21	None	15	2nd	
5	CNI-5H-27	Agawam	mufs190-1952-cni5h27-i001-001.tif	106055.753	869984.1316			1		AH	5/6/21	Whole image	15	2nd	
6	CNI-5H-28	Agawam	mufs190-1952-cni5h28-i001-001.tif	106098.0864	871592.8015			1		AH	5/7/21	None	16	2nd	
7	CNI-5H-96	Agawam	mufs190-1952-cni5h96-i001-001.tif						1	AH	5/11/21	None	8	2nd	
8	CNI-5H-97	Agawam	mufs190-1952-cni5h97-i001-001.tif	102478.4228	866544.7615			1		AH	5/7/21	Whole image	16	2nd	
9	CNI-5H-98	Agawam	mufs190-1952-cni5h98-i001-001.tif	102451.9645	868211.6398			1		AH	5/9/21	None	17	2nd	
10	CNI-5H-99	Agawam	mufs190-1952-cni5h99-i001-001.tif	102399.0477	870010.8101			1		AH	5/9/21	Whole image	15	2nd	
11	CNI-5H-100	Agawam	mufs190-1952-cni5h100-i001-001.tif	102451.9645	871651.23			1		AH	5/9/21	None	15	2nd	
12	CNI-6H-136	Agawam	mufs190-1952-cni6h136-i001-001.tif	108915.8939	870201.1537			1		AH	5/11/21	Part of image	16	2nd	
13	CNI-6H-137	Agawam	mufs190-1952-cni6h137-i001-001.tif	109021.7275	868994.6513			1		AH	5/11/21	Whole image	16	2nd	
14	DPB-4H-154	Amherst	mufs190-1952-dpb4h154-i001-001.tif	118774.3684	896141.7735			1		AH	3/26/21	None	16	2nd	
15	DPB-4H-155	Amherst	mufs190-1952-dpb4h155-i001-001.tif	118807.8964	897918.7611			1		AH	3/26/21	Whole image	16	2nd	
16	DPB-4H-156	Amherst	mufs190-1952-dpb4h156-i001-001.tif	119009.0648	900047.7933			1		AH	3/26/21	Part of image	15	2nd	
17	DPB-4H-157	Amherst	mufs190-1952-dpb4h157-i001-001.tif	118942.0087	902411.522			1		AH	3/27/21	Whole image	18	2nd	
18	DPB-4H-158	Amherst	mufs190-1952-dpb4h158-i001-001.tif	118874.9526	903804.6132			1		AH	3/27/21	Whole image	16	2nd	
19	DPB-4H-159	Amherst	mufs190-1952-dpb4h159-i001-001.tif	118791.1324	905548.0727			1		AH	3/27/21	None	15	2nd	
20	DPB-4H-160	Amherst	mufs190-1952-dpb4h160-i001-001.tif	118908.4806	907475.9366			1		AH	3/30/21	None	15	2nd	
21	DPB-6H-54	Amherst	mufs190-1952-dpb6h54-i001-001.tif	115860.9557	908333.7737			1		AH	4/2/21	Part of image	17	2nd	
22	DPB-6H-55	Amherst	mufs190-1952-dpb6h55-i001-001.tif	115860.9557	908333.7737			1		AH	4/2/21	None	16	2nd	

Georeferencing Process

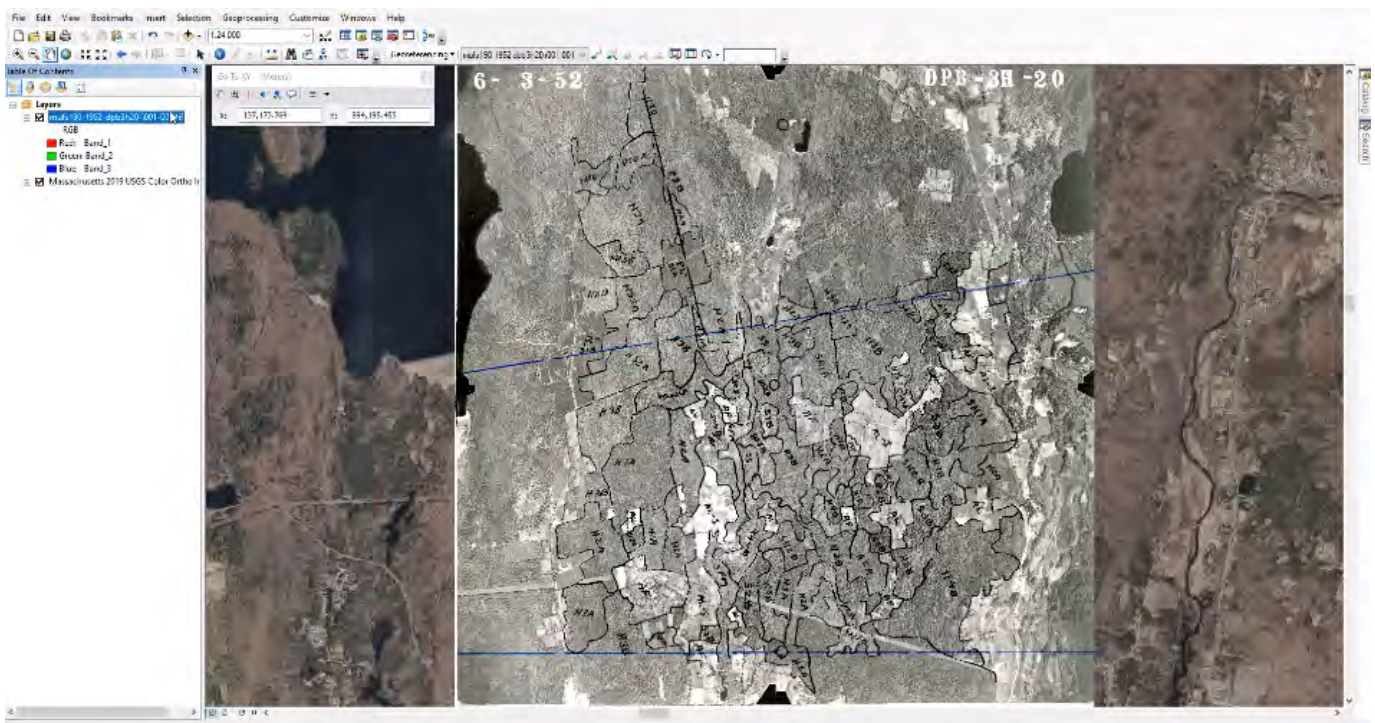
Step 1: Insert the Aerial Photo

- Open your Catalog and insert the .tiff aerial photo for the geographical location you are working with
- Have the index point coordinates for your .tif aerial photo ready to insert into the "Go To XY" toolbar (make sure the units are meters)
- Use the "flash" button on the toolbar in order to see the point location of the XY coordinates
- Click the "Zoom To" option on the toolbar to zoom to the point location



Step 2: Fit To Display

- Click on the "Map Scale" dropdown window to set the map scale to a comfortable 1:24,000
- In the "Georeferencing" toolbar, click on the "Fit To Display" option in order to move the aerial photo into your screen



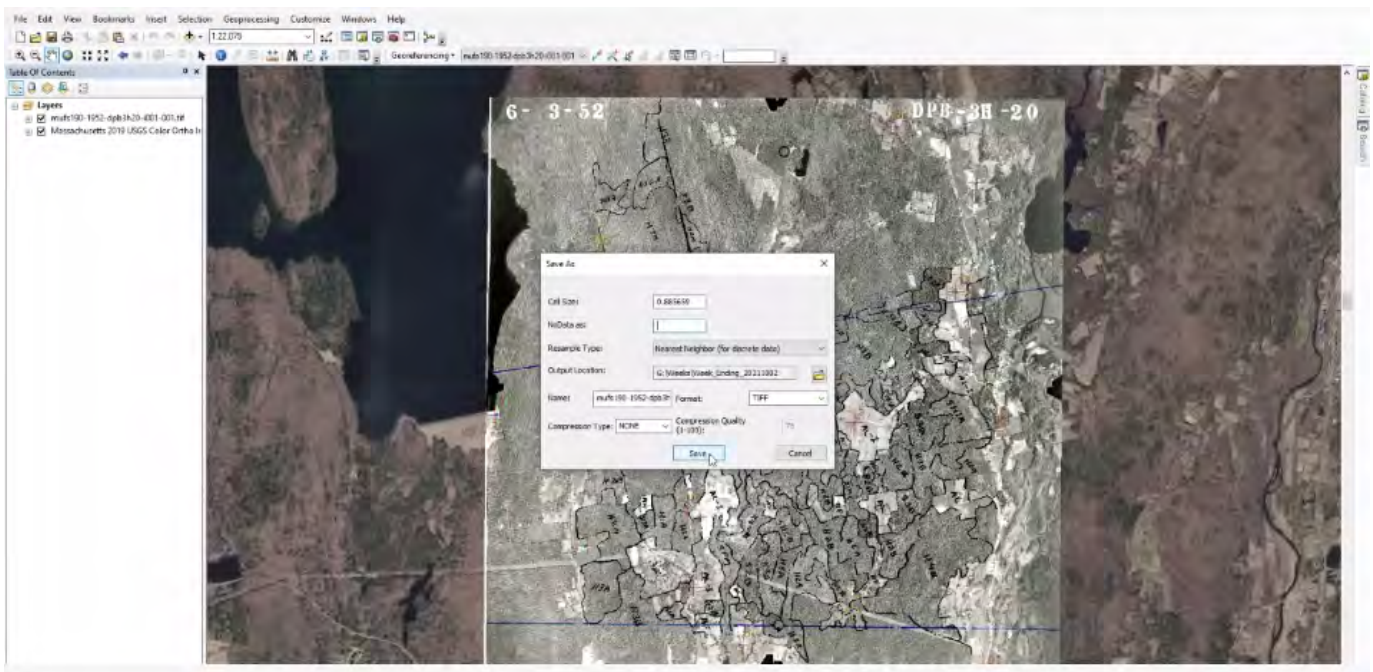
Step 3: Select the Ground Control Points (GCPs)

- Swapping between both views of the MacConnell aerial photo and the Massachusetts orthoimage, take notice of locations that have not seen much change
- Carefully place GCPs in the most ideal locations such as building corners or road intersections
- After three GCPs, the photo is almost aligned with the Massachusetts 2019 orthoimage
- Add additional GCPs until you reach about 14-16 GCPs



Step 4: Rectify the Aerial Photo

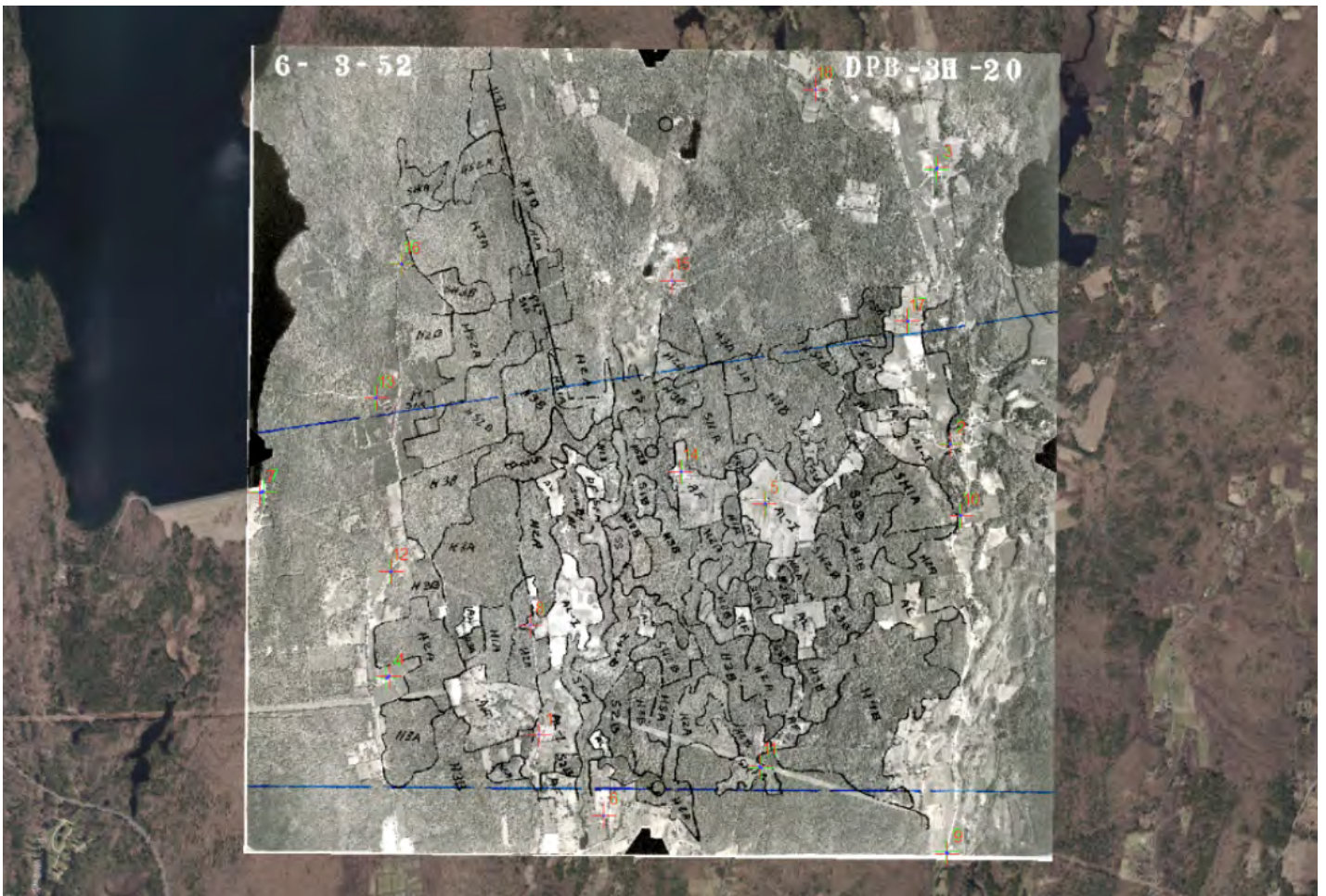
- When done adding points, open the link table and set the transformation type to either first, second, or third-order polynomial (we prefer second-order polynomial)
- To save a copy of the georeferenced photo, click Georeferencing > Rectify... This pulls up the "Save As" dialog
- Delete the "NoData" value (this ensures the output pixel type is 8-bit unsigned)
- Click the "Save" button to export the image when satisfied with the GCPs



Our goal is to aim for about 16 ground control points, although this may not be feasible for every photo.

In our experience, we were able to identify 14 to 20 GCPs on photos with easily identifiable building corners and road intersections.

We were able to identify anywhere between 8 to 13 on photos with lots of forested areas and water bodies.



GCP Best Practices

Most Ideal GCPs

Locations that stay the same:

- Building corners
- Road intersections
- Railroad lines that are still railroad lines

Building corners stand out most when trying to capture the perfect ground control point.

Going through the MacConnell Aerial Photo Collection, we find that factory buildings, barns, and some houses largely stayed the same.

Location: Russell, Massachusetts



Less Ideal GCPs

Locations that can potentially move:

- Recreational features that are movable (home plate in a baseball diamond)
- Land cover borders (open land, forested areas, water bodies)
- Individual trees, brushes, or shrubs
- Road edges
- Railroad lines that have been turned into trails

Location: Ware, Massachusetts



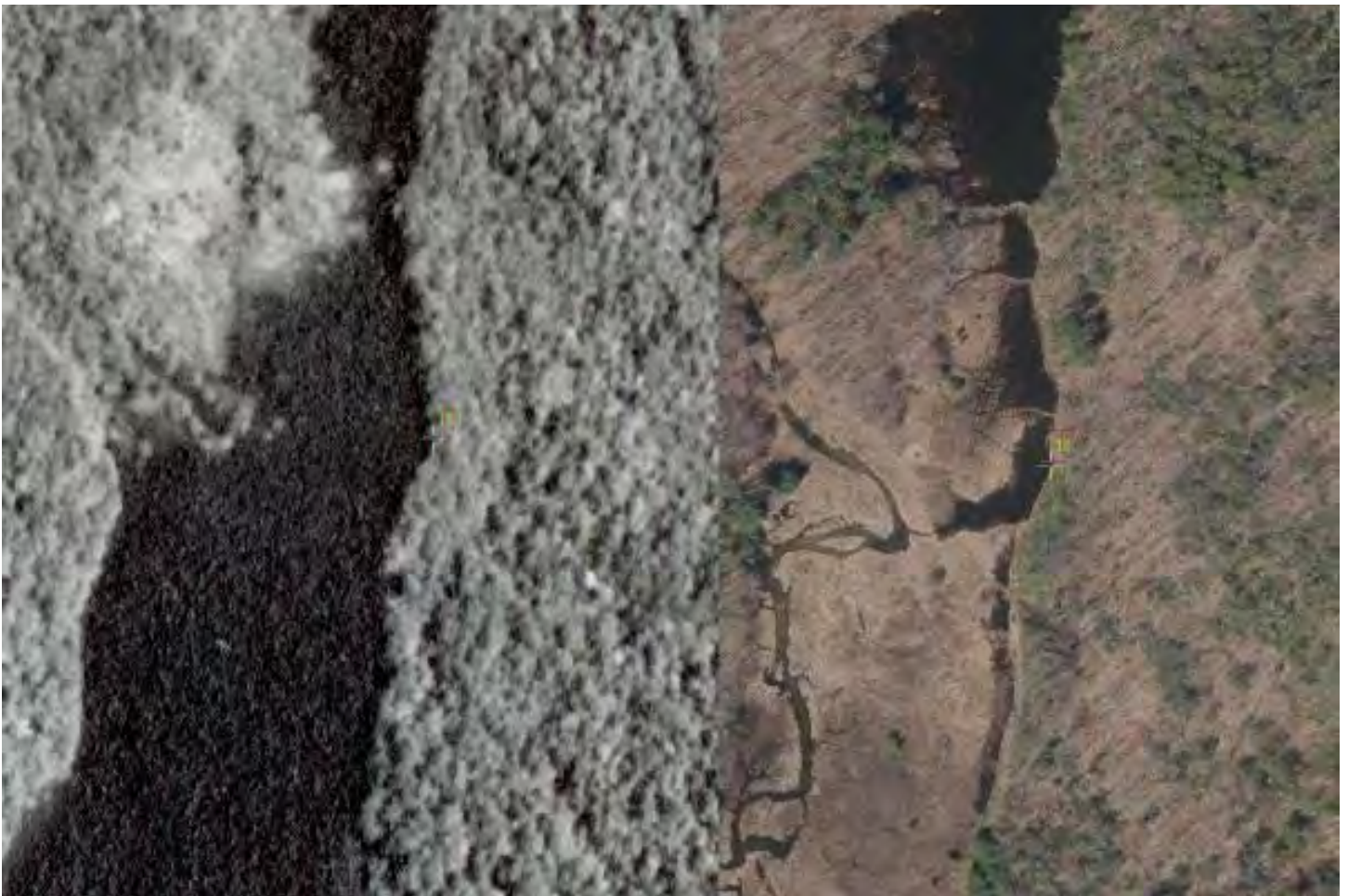
Least Ideal GCPs

Locations that are likely to have changed:

- Open land
- Forested areas
- Water bodies

Location: Southampton, Massachusetts

(Image only for presentation purposes, not an actual GCP used)



Before/After Images

Montgomery, Massachusetts

1952 / 2019

Before and after:

The Tighe Carmody Reservoir was constructed in 1957. It can be seen in the upper-right corner of the "after" photo.



West Springfield, Massachusetts

1952 / 2019

Before and after:

Major rural-to-suburban development can be seen in the upper half of the "after" photo.

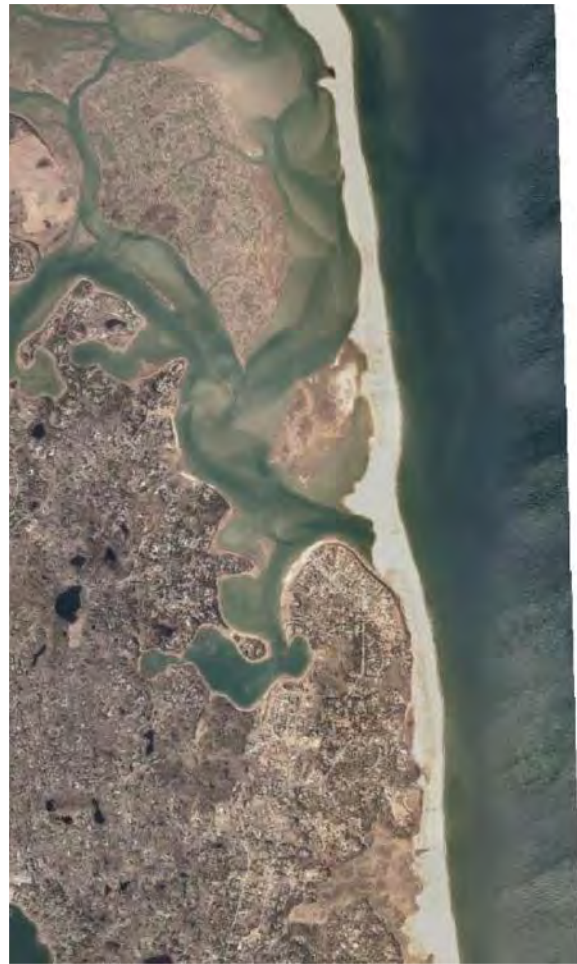


Eastham, Massachusetts

1952 / 2019

Before and after:

Major beach and fluvial change is apparent.



Boston, Massachusetts

1952 / 2019

Before and after:

Major infrastructure development took place after 1952. Interstate 93 was constructed in 1957 and can be seen in the "after" photo heading north from downtown Boston.



Challenges

Several images, especially in Western Massachusetts, have very few human-made structures and are mostly covered in forests. These images were difficult to georeference because there are very few similar ground control points that can be distinguished between 1950 and 2019.



Image from Granville, Massachusetts

Other images had slight distortion due to elevation changes in mountainous areas. These were also concentrated in Western Massachusetts. The example below was distorted because there are mountains with steep elevation gain in the middle. If you look closely at the small lake circled by the mouse, it changes position significantly despite the rest of the image being georeferenced.

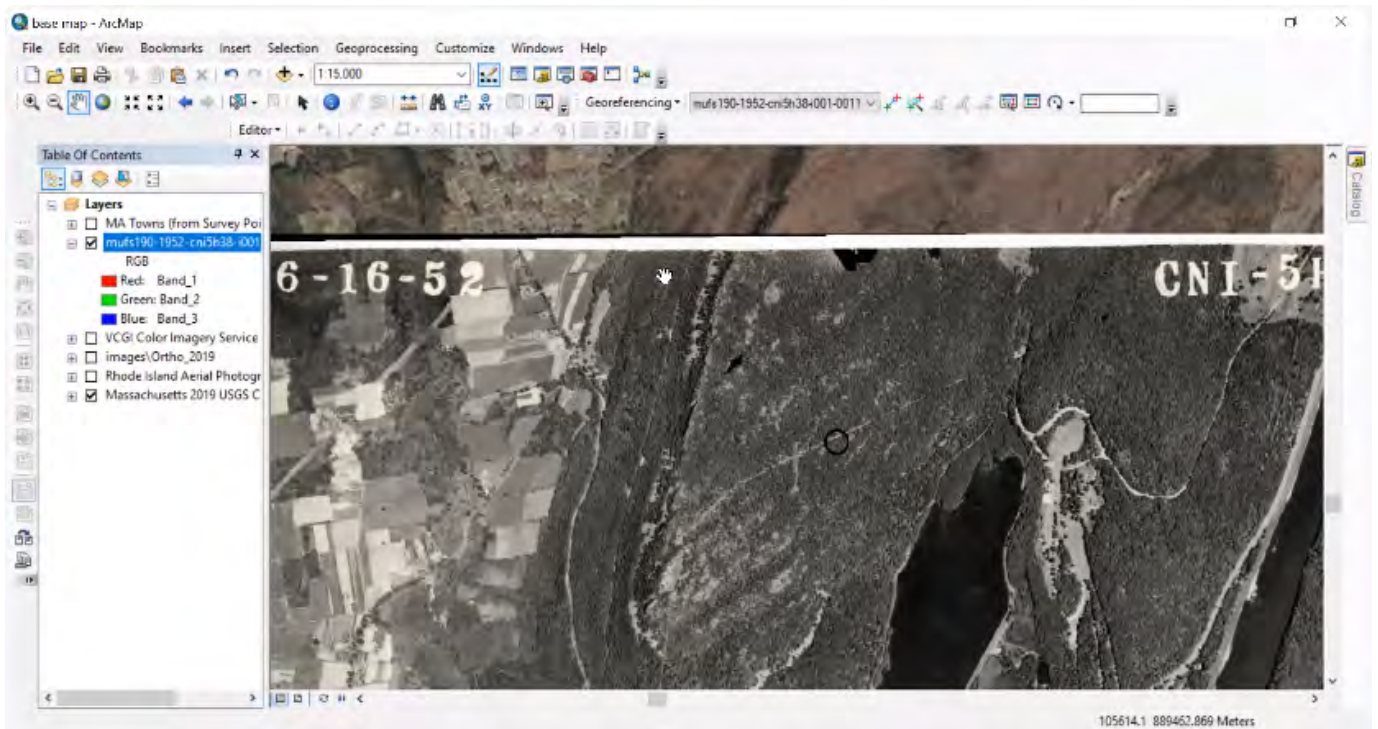


Image from Holyoke, MA

Ongoing Work

To date, the team has georeferenced 700 images. The end goal will be to host the photos on a geoportal through UMass Amherst Libraries where anyone can access and download georeferenced images from the 1950s from any part of Massachusetts. The geoportal is currently in development and we expect it to be launched in 2022.

Apart from this project, we also worked with an external team to develop an automated GCP-generating process. This process involved inserting the MacConnell index numbers into a command line prompt and automatically detecting a predetermined number of GCPs for each inserted photo. With some improvements in the future, this software could be used to make the georeferencing process much quicker.

Overall, the project has already produced a significant body of georeferenced aerial photos from the 1950s. The MacConnell collection predates the aerial photos available through MassGIS by 40 years, making this the earliest imagery of Massachusetts and a rich dataset that documents the dramatic transformations in the landscape that have taken place in the last several decades.

While we await the launch of the geoportal, you can browse the photos from the MacConnell collection through our [Special Collections & University Archives](#) and use a [web map](#) we created to find specific photos of your location.

Credits

Funding for this project was provided through the UMass Amherst Interdisciplinary Faculty Research Awards. Special thanks to UMass Amherst Libraries' Special Collections and University Archives, the Department of Landscape Architecture and Regional Planning, and the Department of Geosciences.

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Credo

<https://credo.library.umass.edu/view/collection/mufs190>

Web Map

<https://arcg.is/qGe1>