

Georeferencing with QGIS

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Module Licensing Information

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Reviewed by

Scan the map section - important note needs a second look, should not be advising to scan as jpeg if QGIS still can't handle them. (3 Feb 2007)

In linux (ubuntu) .8 crashes when I try to refresh after setting the projection for the two layers. (4 Feb 2007)

Michael Hamel

Overview

A common GIS development task is the need to digitize data off of a paper map. There are two main ways to do this:

1. Digitize using a digitizing tablet.
2. On-screen digitizing from a background (scanned) image of the map.

This document describes part of the process for on-screen (#2) digitizing: Getting a background image georeferenced so that you can do online digitizing using it, or simply use it as another GIS (raster) layer.

1. First, you must identify the map you want to digitize and check it for metadata.
 1. Check for georeferencing coordinates (are there long/lat lines on the map? UTM coordinates? What kind of datum/map projection is it in?) ([See Appendix A](#) for an example from a USGS topomap).
 2. You must also check for some usable Ground Control Points. These are points on the coordinate grid that you can easily see and calculate X,Y coordinates based on the projection the map is in. ([See Appendix A](#))

Scan the map to a TIFF file

Important: the current version of QGIS was tested for *GeoTiff* format only. So we will use only TIFF format for the lab. There is a problem with image rendering on QGIS for Windows. Apparently, QGIS can render ONLY georeferenced images. When I tried to open an image (w/o georef) the system shows it in TOC, but there is no image on the map canvas. For the exercise we use **amherstopo.tif** image, not the JPEG.

You need a scanner to scan your map. If it is a large map, you need a large (map) scanner. For projects, it will probably be better for you to try and work with maps that fit on an 8 x 11 sheet of paper.

Before you do the scan, make sure you note the coordinates of grid lines that will be in your scanned image. Refer to Appendix A “Amherst Topo Map” as an example. It is critical that you include some grid “crosshairs” that you can use as ground control points.

Scan the map to a TIFF file (or better yet a jpg file if the scanner software will do it). Refer to [Appendix B](#), to learn about different image formats.

To use the .tif(.jpg) file in a GIS we must first georeference it. If we brought it into a GIS package (QGIS in our case) as it is, it would have a simple Cartesian plane coordinate system that is based on the number of pixels in the file. We want to assign the .tif(.jpg) file to the correct projection system that it represents, and thus change the coordinate system to represent this projection.

This involves (a) specifying the .tif (or .jpg's) coordinate system in QGIS; (b) Digitizing specific control points; and (c) Rectifying or “stretching” the scanned image to fit the new projection.

For the remainder of this exercise, please use datasets available at [Appendix C](#)

Specifying the coordinate system for the image

It is important to figure out cartographic information for images you plan to add spatial reference to. Read the data description section of the map to define projection, datum and units for the map. In this exercise we get the following from the [data description section](#):

- **Projection:** Universal Transverse Mercator
- **Datum:** 1927 North American Datum
- **Zone:** 18N
- **Map Units:** meters

At the next step we need to identify several points on the image for which it is possible to define coordinates. It is easier to select points located on "cross-hair" of the map.

Figure 1: Defining coordinates of a control point

We use [the scanned topo map](#) to find out coordinates for four points. A [detailed image](#) is also available. The Table below summarizes X(East)/Y(North) coordinates for four control points:

The Table below summarizes X(East)/Y(North) coordinates for four control points:

Ground Control Points with coordinates

GCP ID	X (East)	Y (North)
Point1	703000	4695000
Point2	703000	4699000
Point3	705000	4699000
Point4	705000	4695000

Figure 1: We will use this information to georeference the topo image.

Georeferencing an Image with Georeferencing Tool/Extension

Making Plugin available

QGIS allows users to expand functionality of the application through additional modules or *plug-ins*. We need to add the Georeferencer plug-in to QGIS first. Click on **Plugins > Plugin Manager** on the main menu bar (Figure 2).

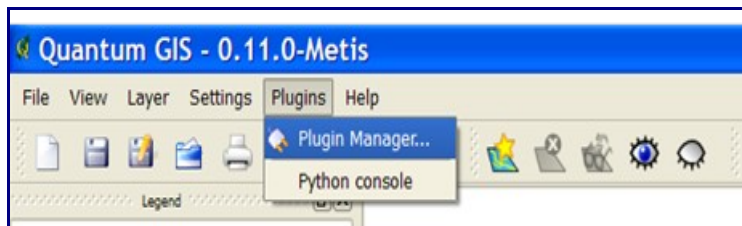


Figure 2: Invoke Plugin Manager

The window with a list of available plugins will appear. Be sure that you check the *Georeferencer* plugin (Figure Ref).



Figure 3: Plugins Manager window

The Georeferencer plugin is now available on the system. In some versions of QGIS its button will appear on the menu bar (Figure 4a), in other versions you should click on **Plugins > Georeferencer > Georeferencer** (Figure 4b).



Figure 4a: QGIS menu bar with a new button

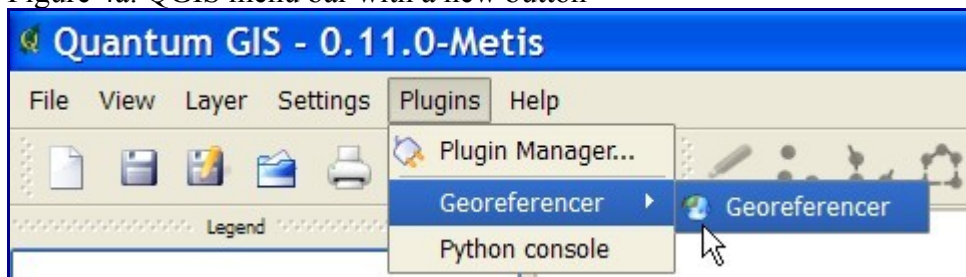


Figure 4b: QGIS menu bar

Now we can start using the georeferencing functionality of *QGIS*.

Georeferencing procedure

This section describes the major steps to georeference the image (Note: you do not need to add the image (raster) to the QGIS project).

1. Start the Georeferencer plugin, it will open the plugin window and the blank main plugin window.
2. Specify the image you would like to georeference by clicking on the [...] button and selecting the file. (This is **amherstopo.tif** in our case.

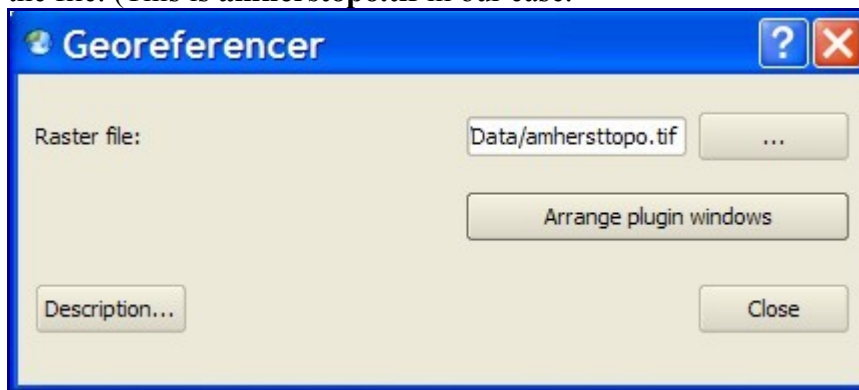


Figure 5: Georeferencer Plugin File Selection

3. The image will appear in the center of the main window.

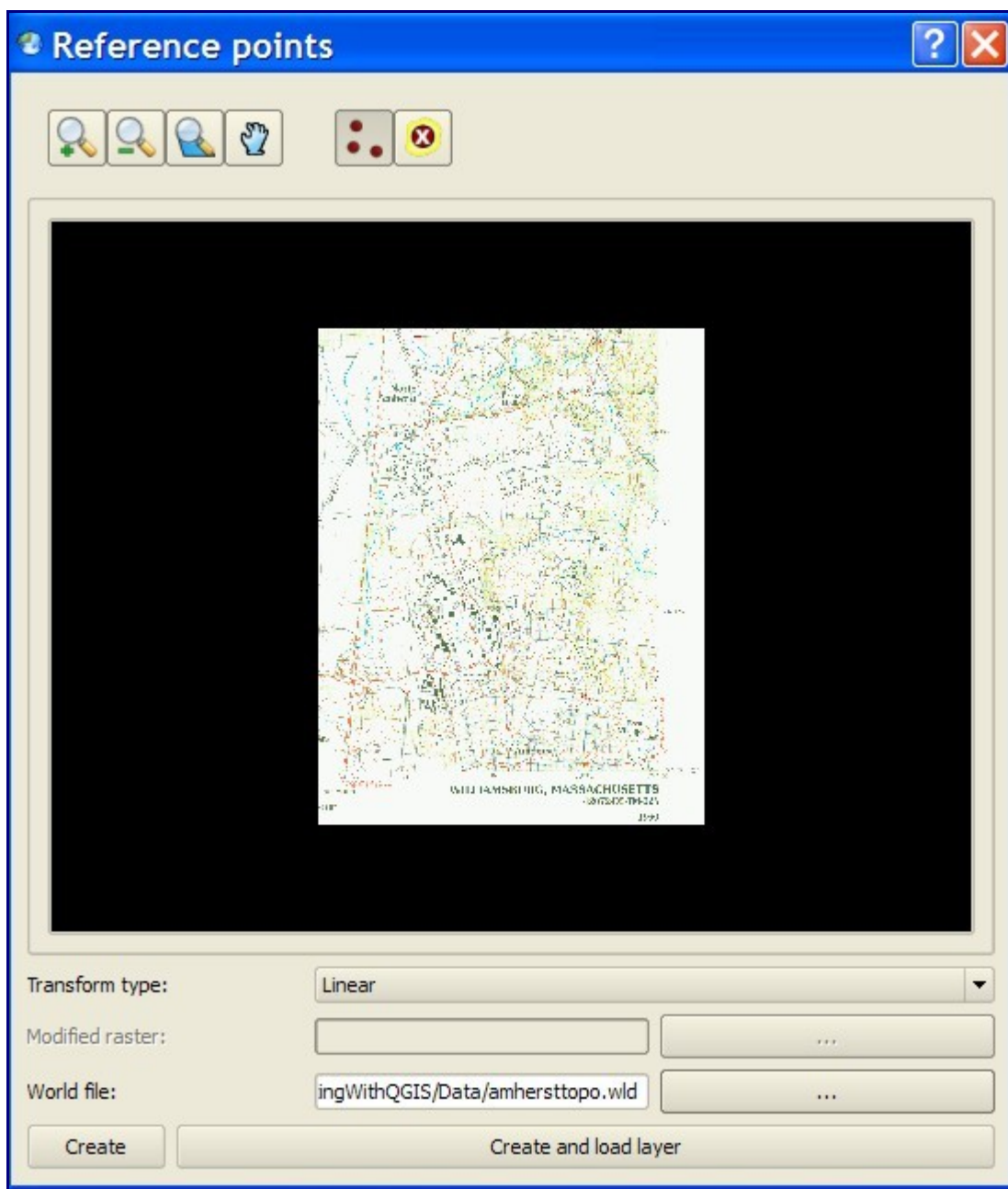


Figure 6: Main Georeferencer Plugin Window

4. Before preceeding further, please take a moment to learn the navigation/control tools of the plugin: *zoom-in*, *zoom-out*, *zoom to full extent*, *pan*, *add control point* and *delete control point*.



Figure 7: Plugin navigation and control tools

5. To add a control point, please zoom to a point you defined earlier (use *zoom* and *pan* tools).

Then click on the *[add control point]* tool, position the cursor over the selected point and left click. A dialog window will appear.

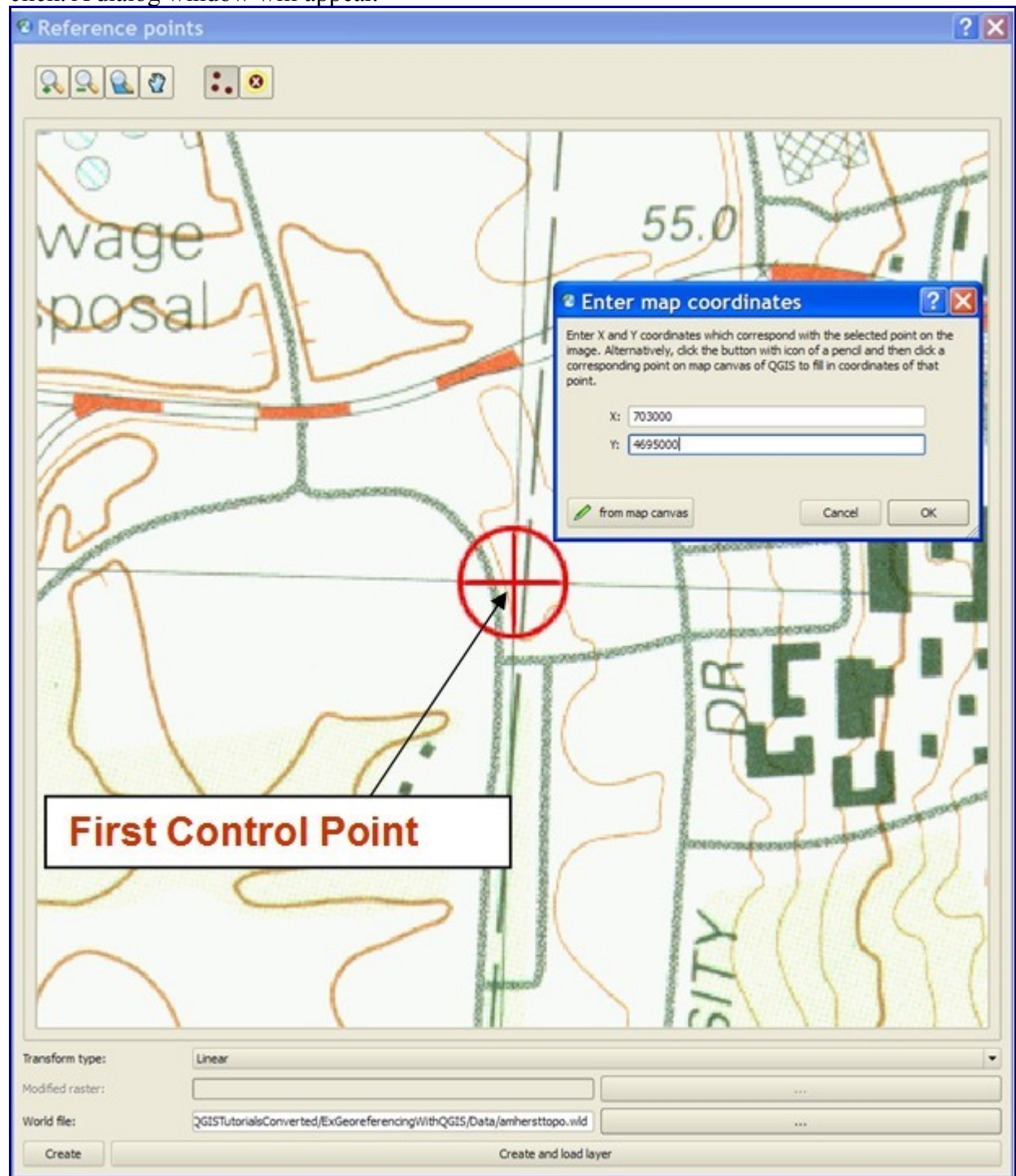


Figure 8: Adding Control Points

Enter the *X/Y* coordinates and press **[Ok]**.

6. You will see a point depicted by QGIS and a yellow text box with coordinates.

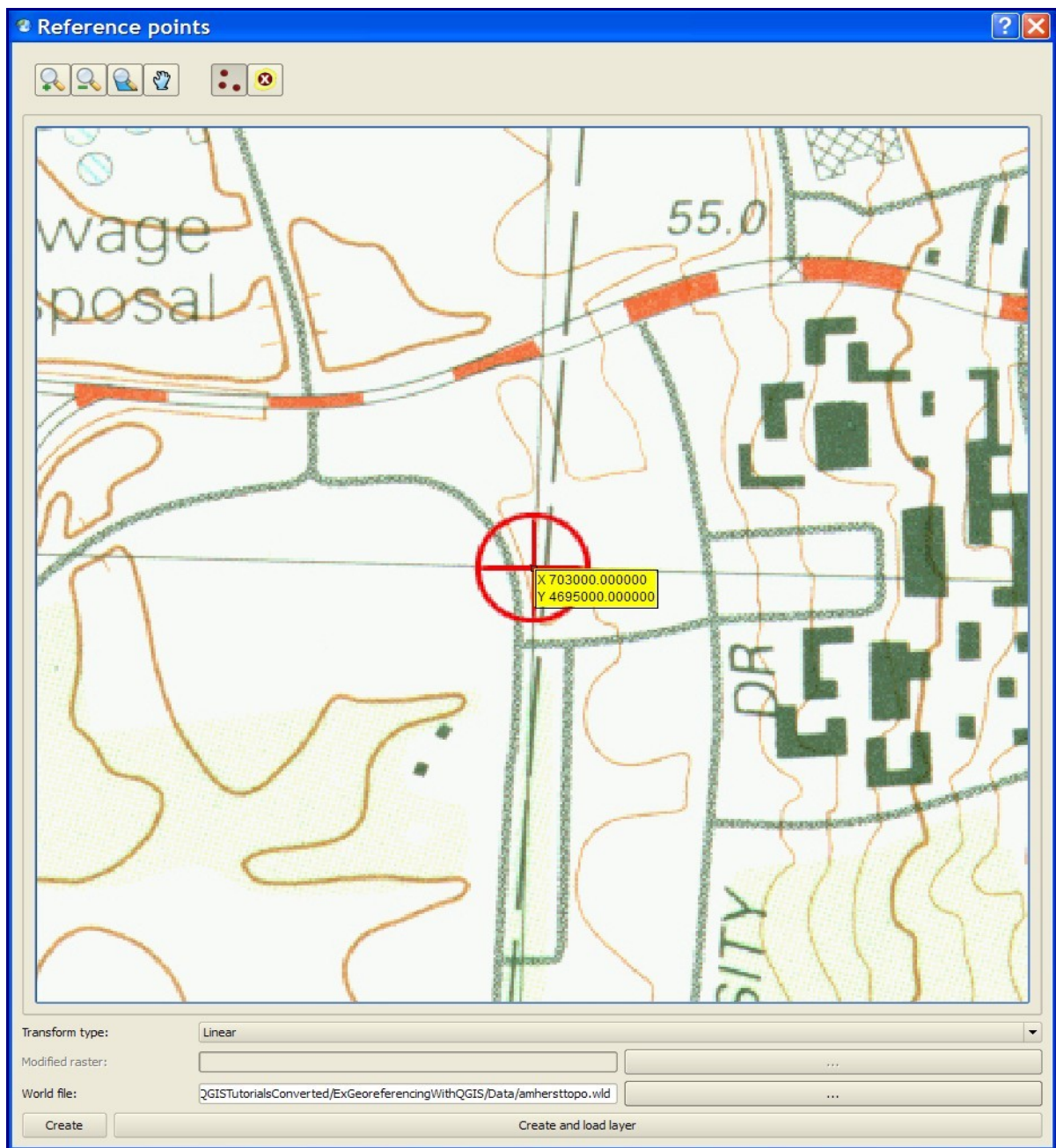


Figure 9: Results of registering point

7. If you make a mistake entering a point, use the *[delete point]* tool to remove the point
8. Repeat steps 5-7 for the other three control points. Be sure that you enter the correct coordinates for each point ([See Appendix A for a closer look](#)).
9. Then click the **[Create]** button (Figure 9.5) and close the Georeferencer window. The 'Create and load layer' button will create a world tiff file AND bring the georeferenced image into the TOC. For now however, we'll just create the world tiff file and load the georeferenced image ourselves so you can see what the world tiff file extension looks like (.wld) in windows explorer.

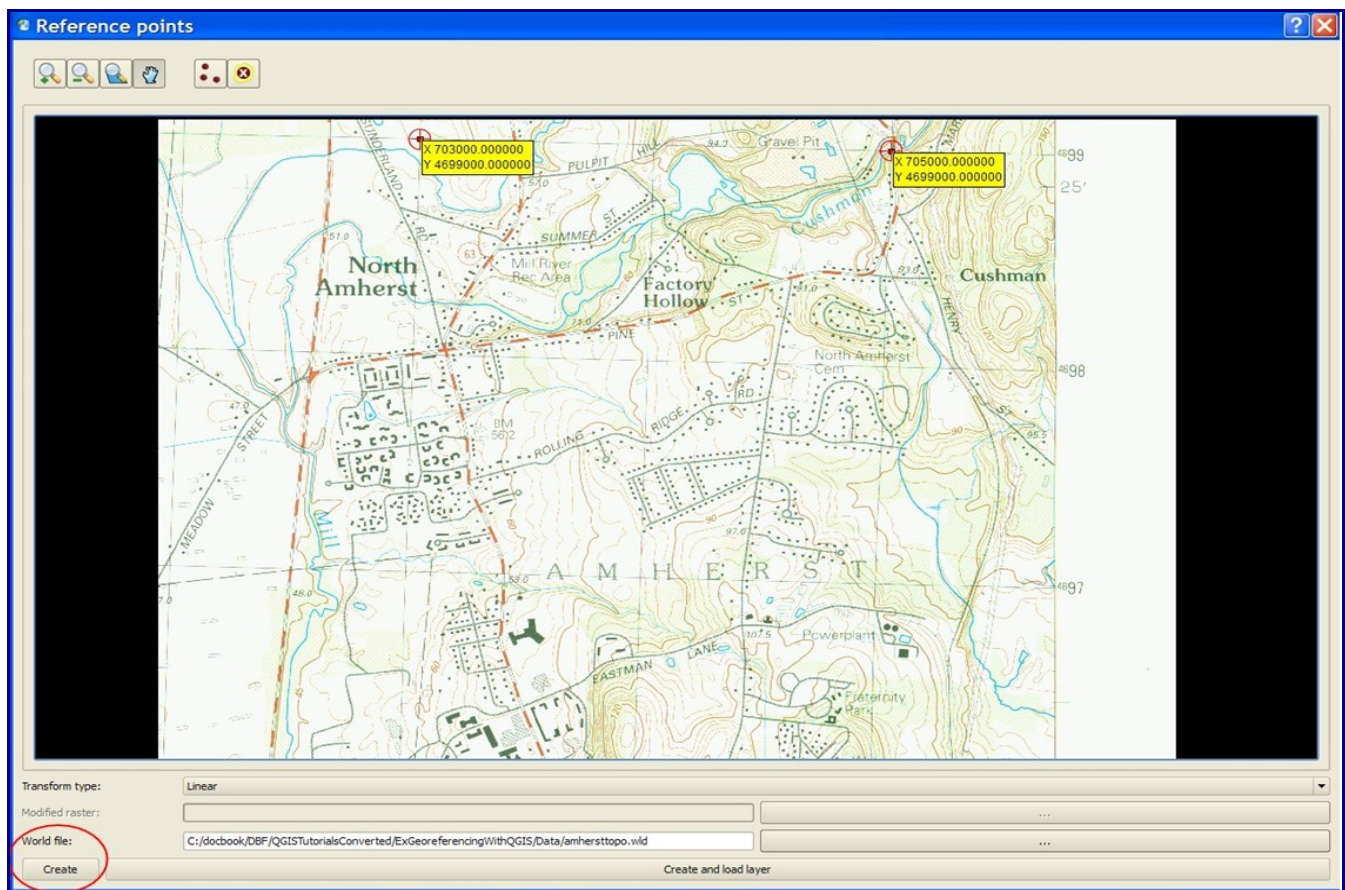


Figure 9.5: Navigation to 'Create' button

Fixing the tif world file: QGIS 0.8.x for Windows ONLY (Error Seems to be Corrected for QGIS 0.11.x- Skip this step)

This sub-step is required only for users of QGIS 0.8.x for Windows. Apparently, the new version of the Georeferencing plug-in (currently 0.8.x) has a bug, which causes incorrect calculations for one parameter in tif-world file. This bug was reported to the QGIS team and is expected to be fixed. Meanwhile, we've devised a workaround for this issue (Sorry--this is a bit complicated and ideally is something you shouldn't have to do if the software is working correctly. Remember QGIS is very new -- we're using a release that is not even version 1.0 yet! -- and the developers are still programming some of the fundamental components. This type of thing is a tradeoff of using newly developed open source software rather than using proprietary software that has been around.)

To "fix" the world file for your "newly" georeferenced tif image you need to:

1. open the **tif world file** for your image (it has the same name as the tif image and a *.wld extension).
 1. you can use any text editor (such as Windows Notepad or Wordpad found under Programs, Accessories) to edit the wld file (Figure 10a)
2. the georeferencing plugin creates a "world file" for the image. This file consists of 6 records: the first four records store information on pixel distortion(s). In other words, how much each pixel should be "stretched/shrunked" to cover correct area. As you see there is nothing really mysterious about the "world" file.

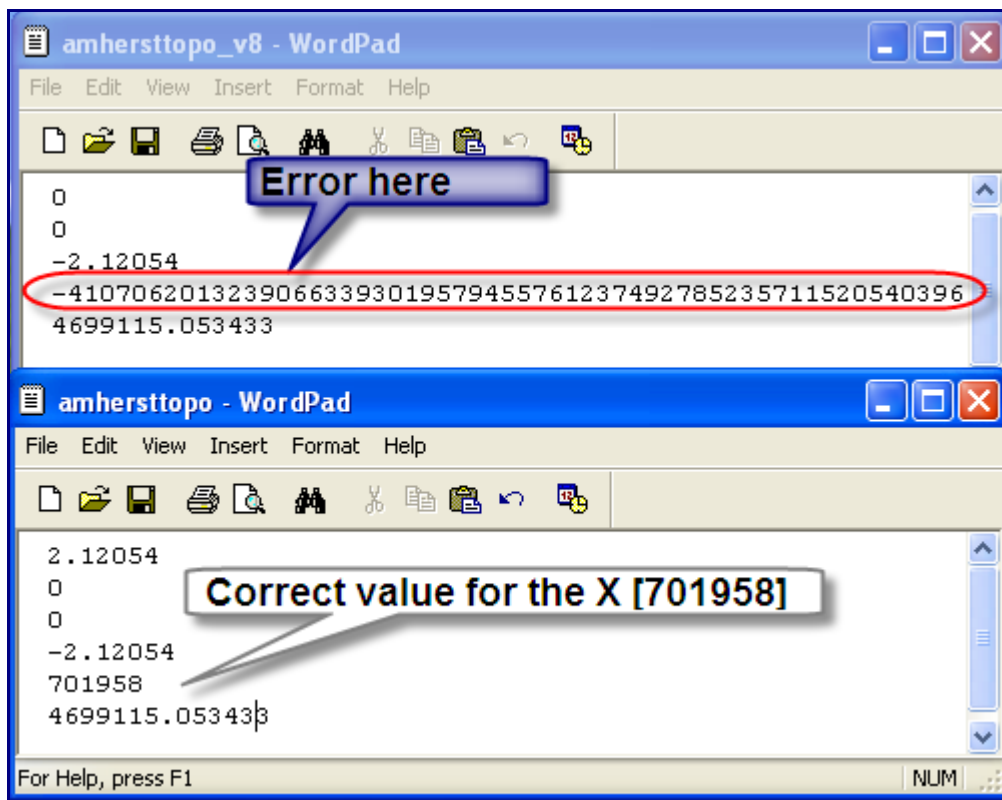


Figure 10a: Correcting the tif world file

Apparently, due to this bug in the software, the plugin computes the X coordinate (number in 5th row) incorrectly. To fix it for the image we are using, please **change the number in the fifth row to 701958**. Then save the file.

Adding data sets with different projections to one map

1. Add the image you georeferenced to the project: [**Layer > Add a Raster Layer**]
2. Add landuse data layer to the project [**Layer > Add a Vector Layer**] and select **lus8.shp**.
3. Set "toggle overview" for both layers. (View> Check 'Overview' at bottom of list) It will allow you to see the spatial extent and a "preview" of layers in the left bottom corner of application.

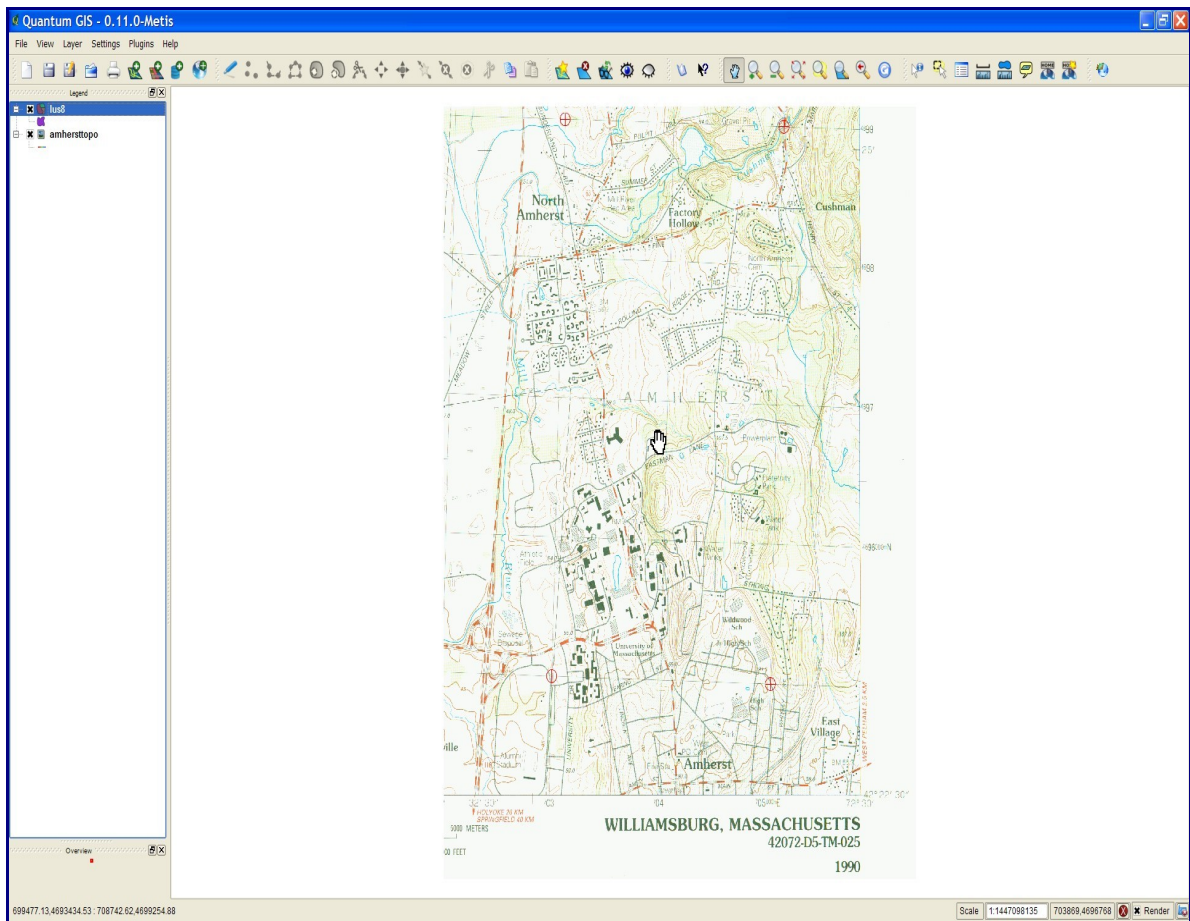


Figure 10: Adding Layers

4. You should notice that these datasets do not overlay. This is because the datasets are prepared with different projections. Modern GIS systems (including QGIS) allows you to reproject datasets "on the fly". You can think of this operation as a *real-time* units/projection conversion. You will need to enable the "on-the-fly" projection option and specify projection information for each layer.
5. Let's enable "on-the-fly" projection and set the default projection for our project. [**Settings** > **Project Properties**], then select the **Projection** tab (See Figure 11 below).

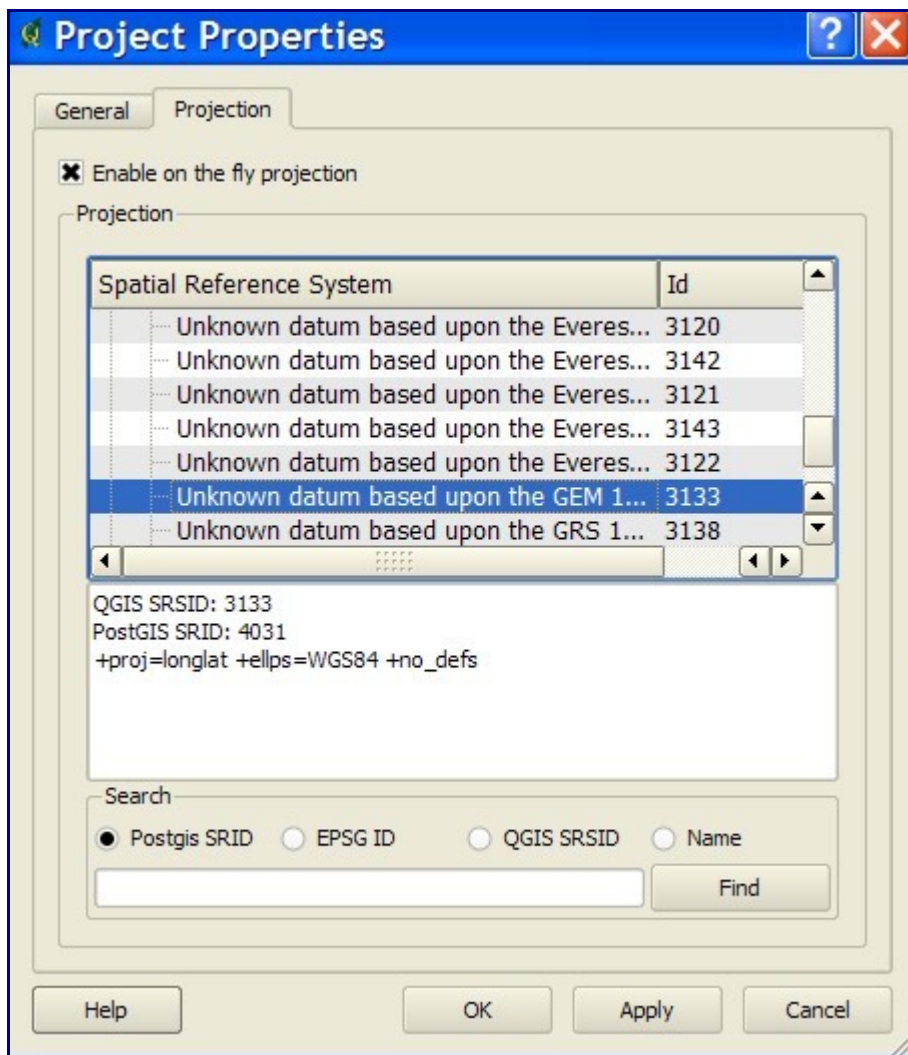


Figure 11: Setting the Projection

Be sure that you check the **Enable on the fly projection** check-box. Then set a projection for the project. There are at least two ways to do that:

1. Select projection via the projection tree/list: **Projected coordinate system > Universal Transv. Mercator > NAD27/UTM zone 18N**. Then click the **[Ok]** button. Please note that this projection setting has a spatial reference ID of 2098. We can use this ID as a shortcut for setting the projection.
 2. Check the **(QGIS SRSID)** radio button. Then enter 2098 into the search text box and click **[Find]**. Select this projection from the list and click **[Ok]**. You'll notice that the raster image disappears from the map view. That's ok. Continue on through the next step and it will come back.
6. Now we must specify the projection information for each dataset/layer.
1. To specify the projection settings for the image, right click on the raster layer in the table of contents (on the left side), select **[Properties]**.

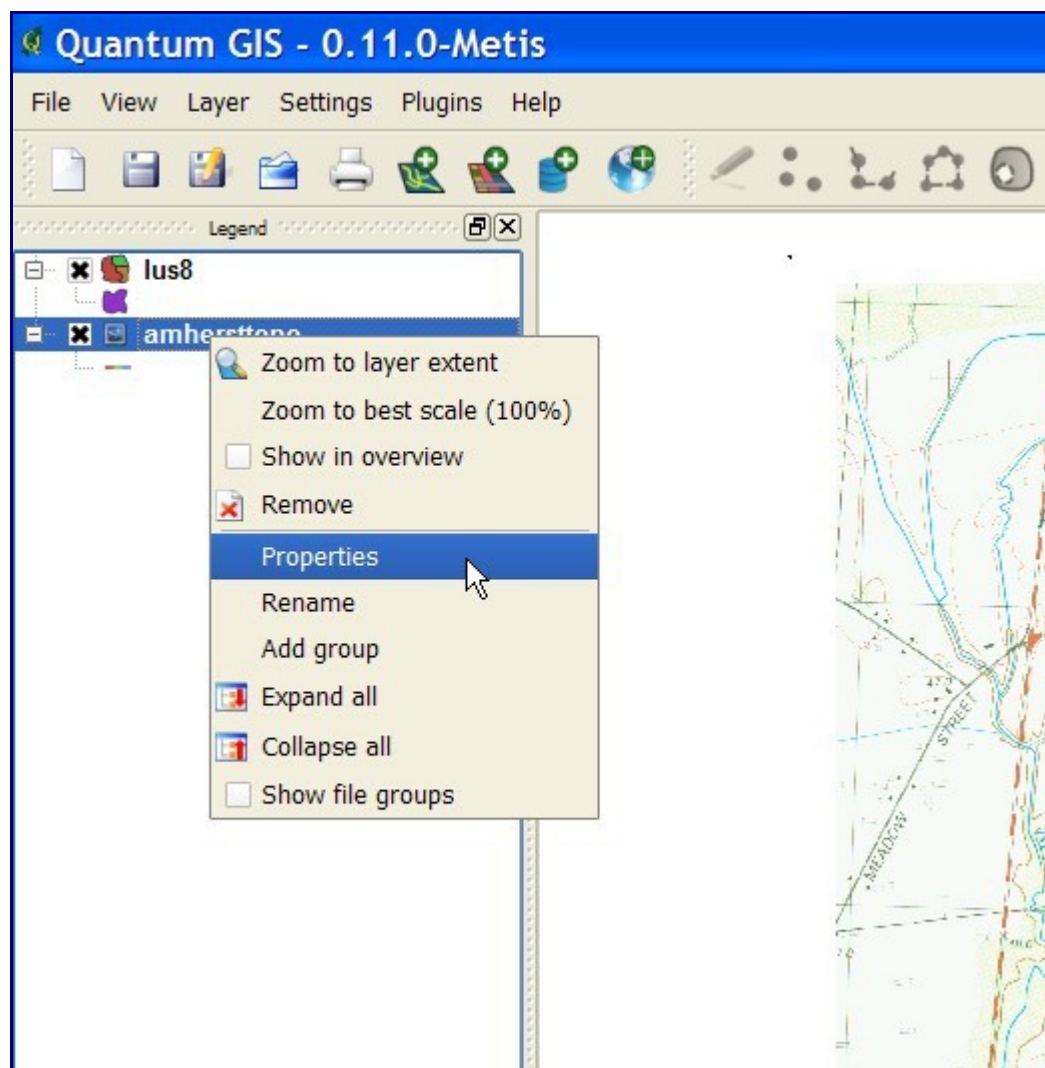


Figure 12: Layer Projection
The "Raster Layer Properties" window will appear.

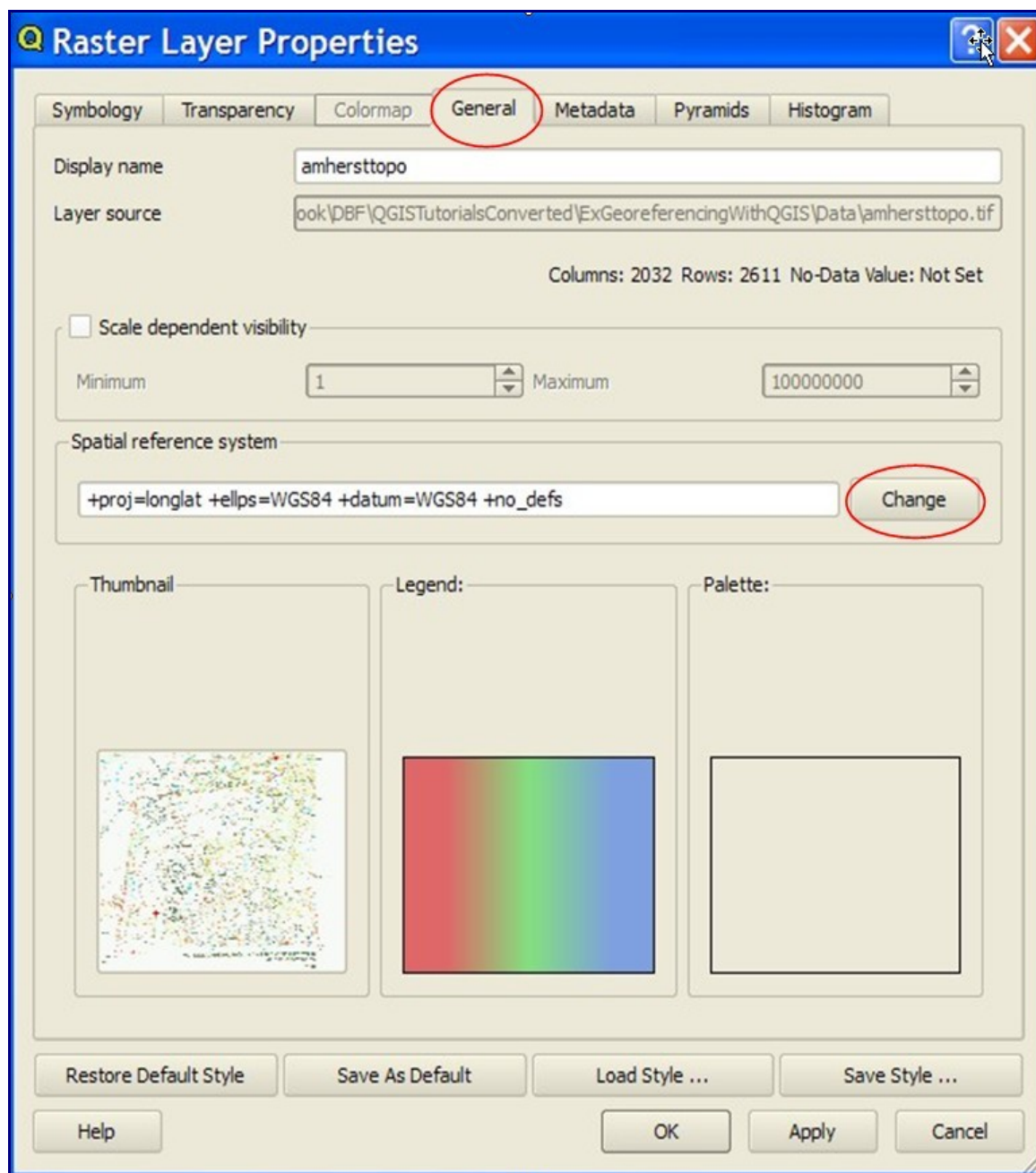


Figure 13: Raster Properties

Select the **[General]** tab. To change the projection click on the **[Change]** button in the "Spatial Reference System" part of the window. The "Layer Projection Selector" window will appear. Use the same steps as we used for defining projection information for the project. (ID 2098, Projected Coordinate Systems > UTM > NAD27/UTM Zone 18N).

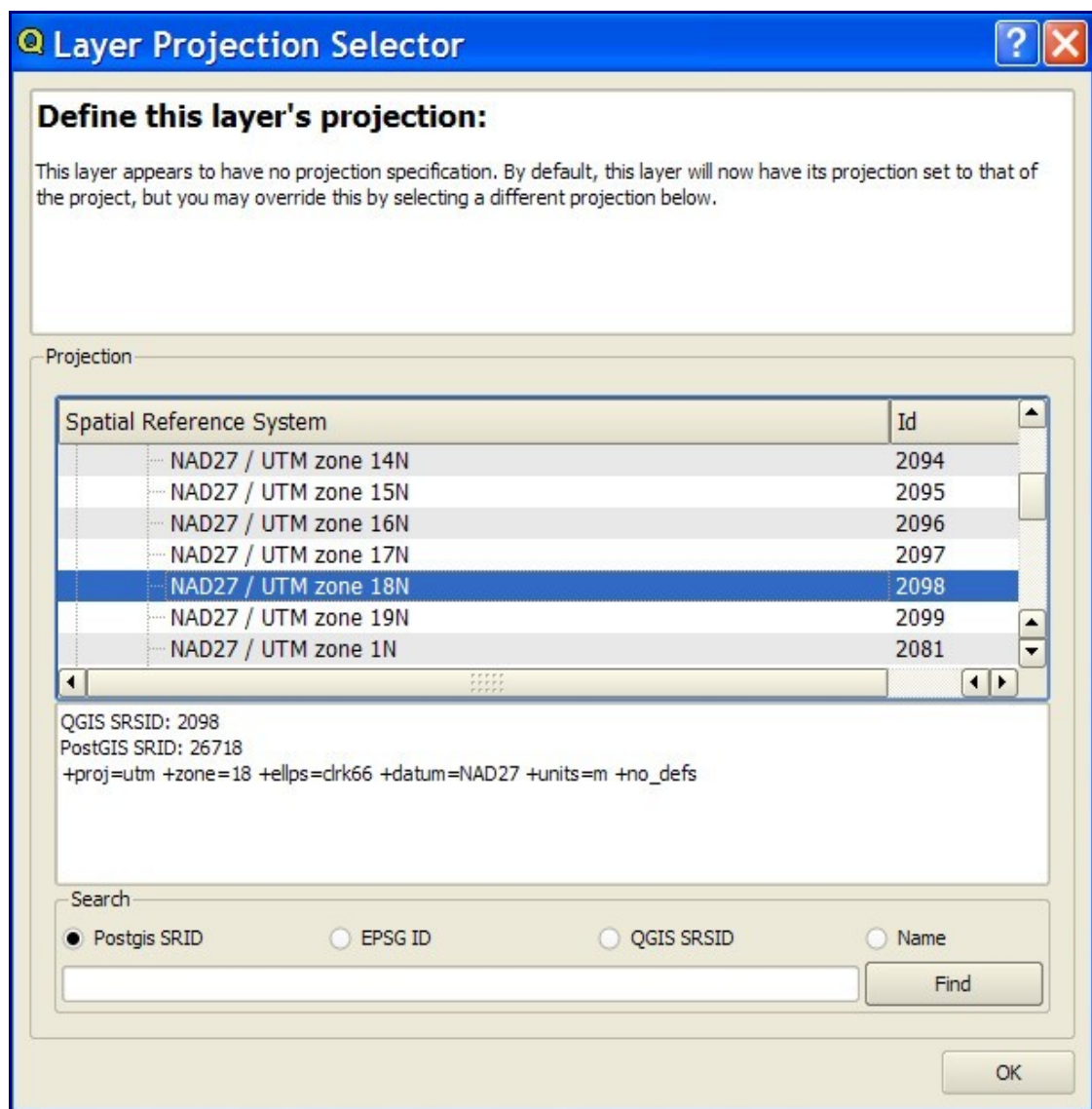


Figure 14: Setting Raster Projection
After that, new projection information is shown in "Spatial Reference System" field.

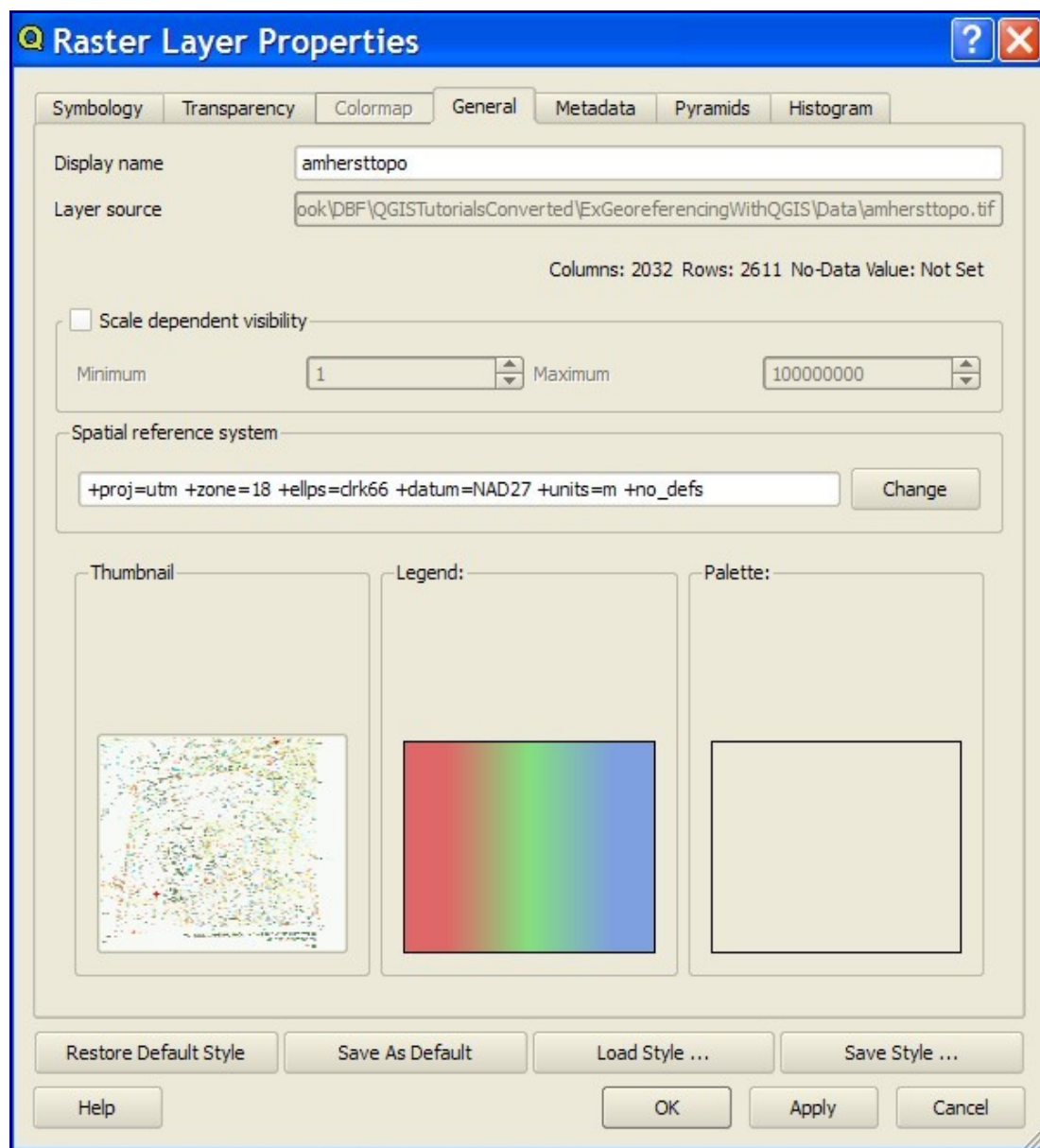


Figure 15: New Raster Projection

1. Setting projection information for the vector layer. At this step, set projection information for the land use layer in the same way that you did for the raster layer, except this time use **ID: 2251 or Projected Coordinate Systems > Lambert Conformal Conic > NAD83/Massachusetts Mainland**
2. The system should be able to "overlay" two datasets. (It should occur automatically, but press the "refresh" button if it doesn't). [Image: .jpg](#)

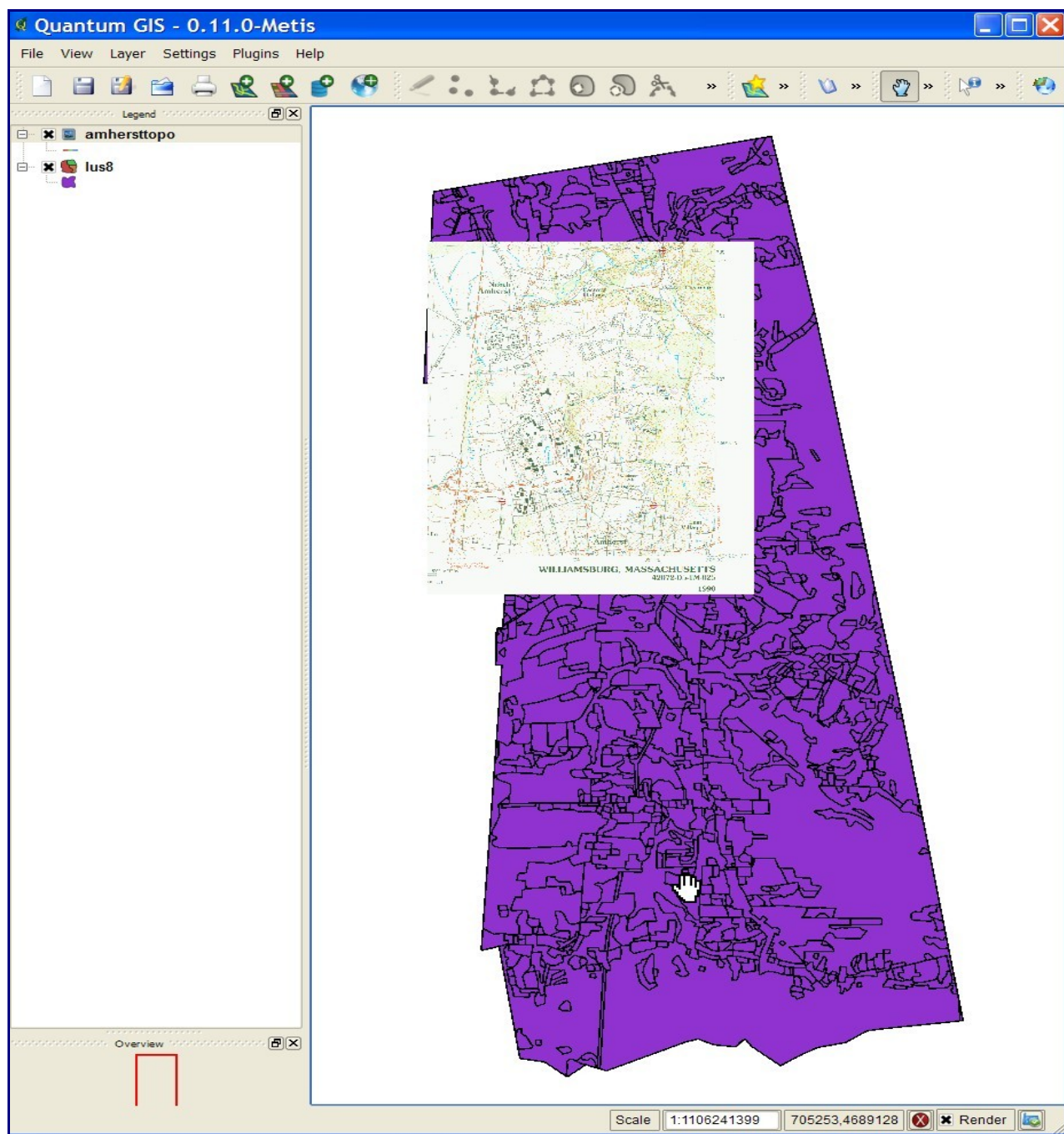


Figure 16: Correctly Projected Layers in QGIS v.0.11.0

Appendix A. Scanned Image, map information

Scanned Topo Image (Amherst, MA)

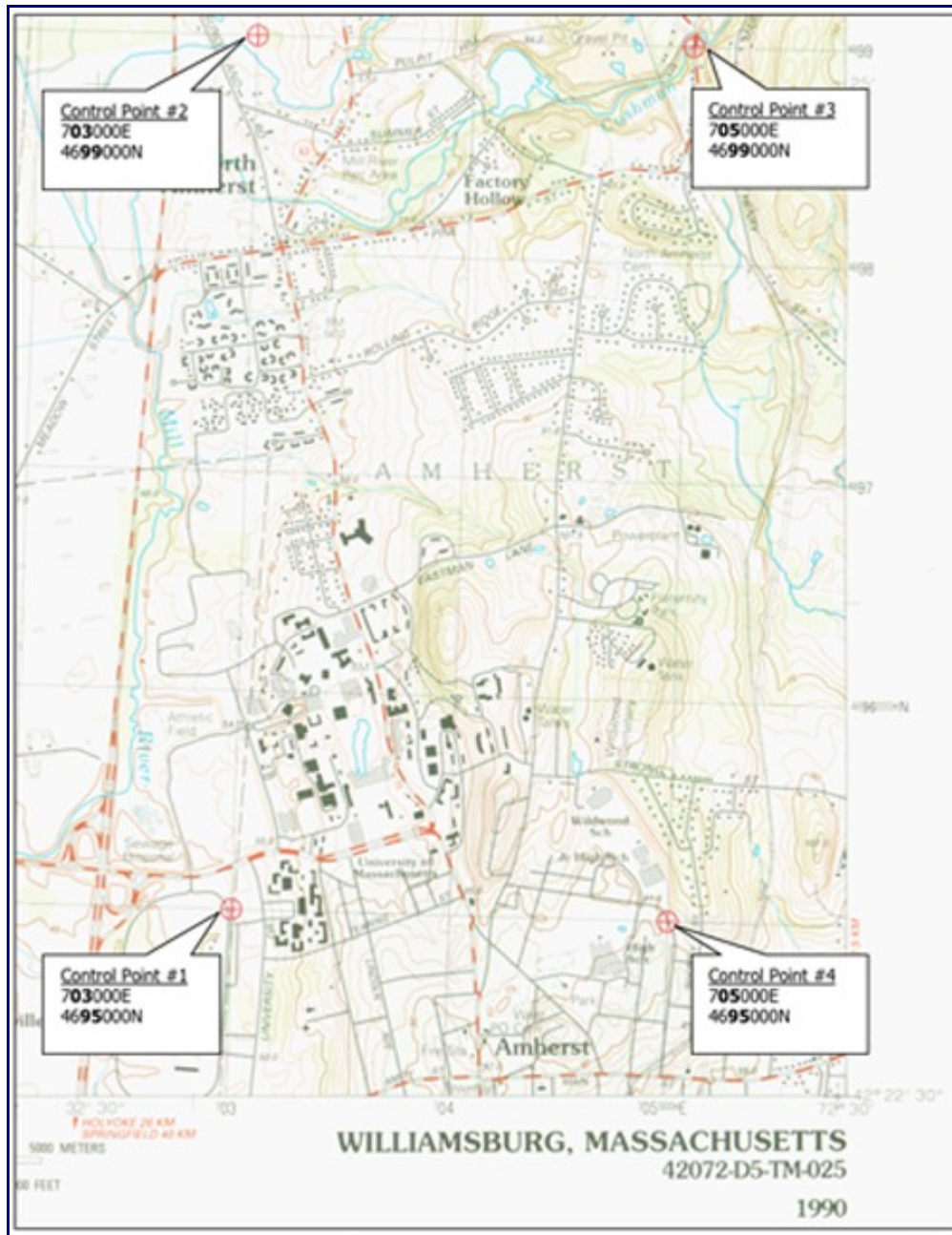


Figure Ref: Scanned Topo with 4 control points defined

Ground Control Points: Details



Figure Ref: Coordinates of Control Points

Metadata

Produced by the United States Geological Survey
Control by USGS, NOS/NOAA, and Commonwealth of Massachusetts agencies

Compiled by photogrammetric methods from aerial photographs taken 1981. Field checked 1984. Map edited 1990
Supersedes Williamsburg 1964 and Mt. Toby 1971
1:25 000-scale maps

Projection and 1000-meter grid, zone 18,
Universal Transverse Mercator
10,000-foot grid ticks based on Massachusetts coordinate system,
mainland zone. 1927 North American Datum
To place on the predicted North American Datum 1983,
move the projection lines 5 meters south and
38 meters west as shown by dashed corner ticks

There may be private inholdings within the boundaries of
the National or State reservations shown on this map

CONTOUR INTERVAL 3 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 METER

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY
P.O. BOX 25286, DENVER, COLORADO 80225

Meters	Feet
1	3.2808
2	6.5617
3	9.8425
4	13.1234
5	16.4042
6	19.6850
7	22.9659
8	26.2467
9	29.5276
10	32.8084

To convert meters to feet
multiply by 3.2808

To convert feet to meters
multiply by 0.3048

DECLINATION DIAGRAM

15°
26.7 MILS
1° 36'
28 MILS

UTM grid convergence
(GN) and 1990 magnetic
declination (MN)
at center of map
Diagram is approximate

1	2	3
4		5
6	7	8

1 Ashfield
2 Greenfield
3 Orange
4 Goshen
5 Shutesbury
6 Chester
7 Easthampton
8 Winsor Dam

ISBN 0-607-23486-5

9 780607 234862

2/3/06

Metadata

MassGIS database projection information

Please check this [website](#) for details on *Massachusetts State Plane coordinate system*.

The datum for the MassGIS database is North American Datum 1983 (NAD83). The data are registered to the Massachusetts State Plane Coordinate System, Mainland Zone (Fipszone 2001). Units are meters. (Some imagery for Martha's Vineyard and Nantucket are also available in the Mass. Stateplane Island Zone).

The Massachusetts State Plane Coordinate System, Mainland Zone meters is defined as follows:

```
Projection:  Lambert Conformal Conic
Spheroid:    GRS 80
Central Meridian: -71.5
Reference Latitude:  41
Standard Parallel 1:  41.71666666667
Standard Parallel 2:  42.68333333333
False Easting:  200000
False Northing:  750000
```

Please note that if you are using data in other projections or in other units (e.g. feet) your data will not be spatially aligned to MassGIS data (unless your GIS software supports on-the-fly projection).

Source: MassGIS website

Appendix B. Comparison of different image formats

What is the difference between TIFF files and JPG files? They are different ways of storing images in a pixel or raster format. Some important information:

- *Pixels* – picture image element
- *Image resolution* – number of pixels in a digital image (higher resolution, better quality)
- *Monochrome image* – each pixel is stored as a single bit (1 or a 0). A 640x480 monochrome image requires 37.5 KB of storage.
- *Gray-scale images* – each pixel is stored as a number between 0 and 255. A 640x480 gray scale image requires over 300KB of storage.
- *8-bit color images* – Each pixel is represented by 1 byte. 256 possible colors out of the millions of colors possible. A 640 x 480 24-bit color image requires 307.2 KB of storage. Requires a color lookup table.
- *24-bit color images* – Each pixel is represented by 3 bytes (e.g., RGB). 256x256x256 possible combined colors (16,777,216). A 640 x 480 24-bit color image requires 921.6 KB of storage.

Some standard system-independent formats

- *GIF* – Graphics Interchange Format. Designed initially to transmit graphical images over phone lines via modems. 8-bit representation (256 colors). Suitable for images with few distinctive colors. GIF works well with images that have only a few colors such as line drawings.
- *JPG* – Joint Photographics Experts Group. Compresses either full-color or grey-scale images. Works well with photographs, artwork, etc., but not well with lettering, simple cartoons, or line drawings. JPEG compression takes advantage of the limitations in human eyesight to make the image represented smaller without compromising what we see as humans. Basic jpeg stores images with 8 bits per color (24 bits for RGB, 8 bits for grey scale).
- *TIFF* – Tagged Image File format. Stores many types of images (monochrome, gray scale, 8bit and 24 bit RGB)

(For some good information on the various graphic file formats, see page 29 of the @OIT Fall 1999, Vol 5 #1, and also the @OIT Spring 2000 page 13 on .jpg compression.)

See also www.cica.indiana.edu/graphics/image.formats.html for information on various types.

Wikipedia provides excellent review of [image formats](#)

Appendix C: Dataset

For this exercise we use a land use vector layer for the Town of Amherst, MA and a scanned topo TIFF image for the same area. Please download archived files from here:

1. [landuse data](#) [0.4Mb]
2. [topo](#) [6.1Mb]
3. You can download landuse file from MassGIS site [directly](#)

Then unzip files into your working/project folder. You should have the following files:

```
amhersttopo.tif  
lus8.dbf  
lus8.prj  
lus8.sbn  
lus8.sbx  
lus8.shp  
lus8.shp.xml  
lus8.shx
```

Sources: [MassGIS Landuse data tiled by town](#)

External Links

- Wikipedia articles on Image Formats: http://en.wikipedia.org/wiki/Image_formats
- GDAL (Geospatial Data Abstraction Library): <http://www.gdal.org>
- FW tools: <http://fwtools.maptools.org/>
- MassGIS: <http://www.mass.gov/mgis/>