

Data conversion/entry (GIS, databases)
November 21 - 25, 2006
Freetown, Sierra Leone

“Heads-up” Digitizing from Scanned Hard-Copy Maps
Part I –Georeferencing Scanned Images¹

Objectives:

- Explore digital archives of scanned legacy mapping.
- Interpret older coordinate systems from map legends.
- Learn how to register scanned hard-copy maps to earth coordinate systems
- Learn the procedures for capturing tie-points (or ground control points) that relate the scanned hard-copy map to earth coordinate systems.
- Learn standard processes used to transform between local (row and column) and earth coordinate systems (such as latitude and longitude).
- Viewing the space requirements for compressed (with loss) .jpg format files.
- Learn the process to permanently georeference scanned maps suitable for use within a GIS

Data Sources:

Table 1. Sierra Leone Data Sources to be used in this lab.

File Name	Description	Metadata	Format	Scale Resolution	Coordinate System
Afr_sl300_1lu	Scanned Hard copy map: Land Systems Sierra Leone.	http://eusoils.jrc.it/esdb_archive/EuDASM/africa/lists/csl.htm	.jpg	1:500,000	<i>Local coordinate system!!</i>
Roads	Roads of the World (Vmap0)	http://www.fao.org/geonetwork/srv/en/metadata.show?id=1280&currTab=simple	ILWIS Segment	1:1,000,000	GCS_WGS_1984
Rivers	Perennial Water Courses (VMap0)	http://www.fao.org/geonetwork/srv/en/metadata.show?id=1269&currTab=simple	ILWIS Segment	1:1,000,000	GCS_WGS_1984

¹ Please quote as:

Kenny F 2006. *Heads-up digitizing from scanned hard-copy maps. Manual on data conversion and data entry (Part I and II), prepared for the FAO project "Land use planning for optimizing agricultural production" - TCP/SIL/3101a, FAO, Rome.*

Background: Data Capture by Scanning

Because the computer allows us to zoom far into images we can work with the mouse and a scanned image which provides much greater accuracy than is possible than using the more traditional digitizing tablet. Scanners are much less expensive than digitizers and are much more accurate. Most people are familiar with scanners, as they can be purchased rather cheaply in office supply stores. However, the scanners you are most familiar with will probably only copy legal size paper. For mapping purposes, scanners have to be much larger, with the ability to accommodate sheet sizes greater than 34", as shown in Figure 1. These devices allow a user to digitally scan a map and perform digitizing on the computer screen (this is called "heads-up" digitizing), thus eliminating the need for a digitizing tablet.



Figure 1. A map scanning system

Processing Steps:

1. In this lab we will first view some scanned Soils maps. If the internet is accessible from your workstation, go to Joint Research Centre's Soils Maps of Africa site. http://eusoiils.jrc.it/esdb_archive/EuDASM/africa/index.htm . Spend some time at this site to become familiar about what this group does and the soils resources available.
2. In particular explore the *Display Maps* option and query or browse your way to Sierra Leone. What you will find here are some 21 scanned hard-copy soils (1951 – 1980) maps for Sierra Leone. This is a very useful resource, not only does it assist with data discovery (note and explore the metadata links), but the scanned maps are also available here to be downloaded utilized. These scanned maps are of a high enough quality to be utilized directly within GIS automation procedures. For this lab we will build directly on these efforts by downloading and georeferencing one of these scanned maps in order to prepare these data for full information extraction in a GIS system. This is a process know as "Heads-Up" digitizing. We will use the Tie-Point, Georeferencing and Digitizing modules in ILWIS software for this lab.

- To save time, I have downloaded the following Map “*Land Systems Sierra Leone. Land Resources and Survey Project SIL/73/002 FAO UNDP-MANR*”. Here is the provided Metadata that describes this Map.

Table 2. Map Metadata

Title:	Land Systems Sierra Leone. Land Resources and Survey Project SIL/73/002 FAO UNDP-MANR.
Author:	Birchall, C.J., Bleeker, P.
Year:	1980
Publisher:	United Nations Development Programme, FAO, Freetown.
Language:	En
Coordinates:	N10°0 - N7°5 W12°10 - W10°35
Scale:	500000
Keywords:	Land use

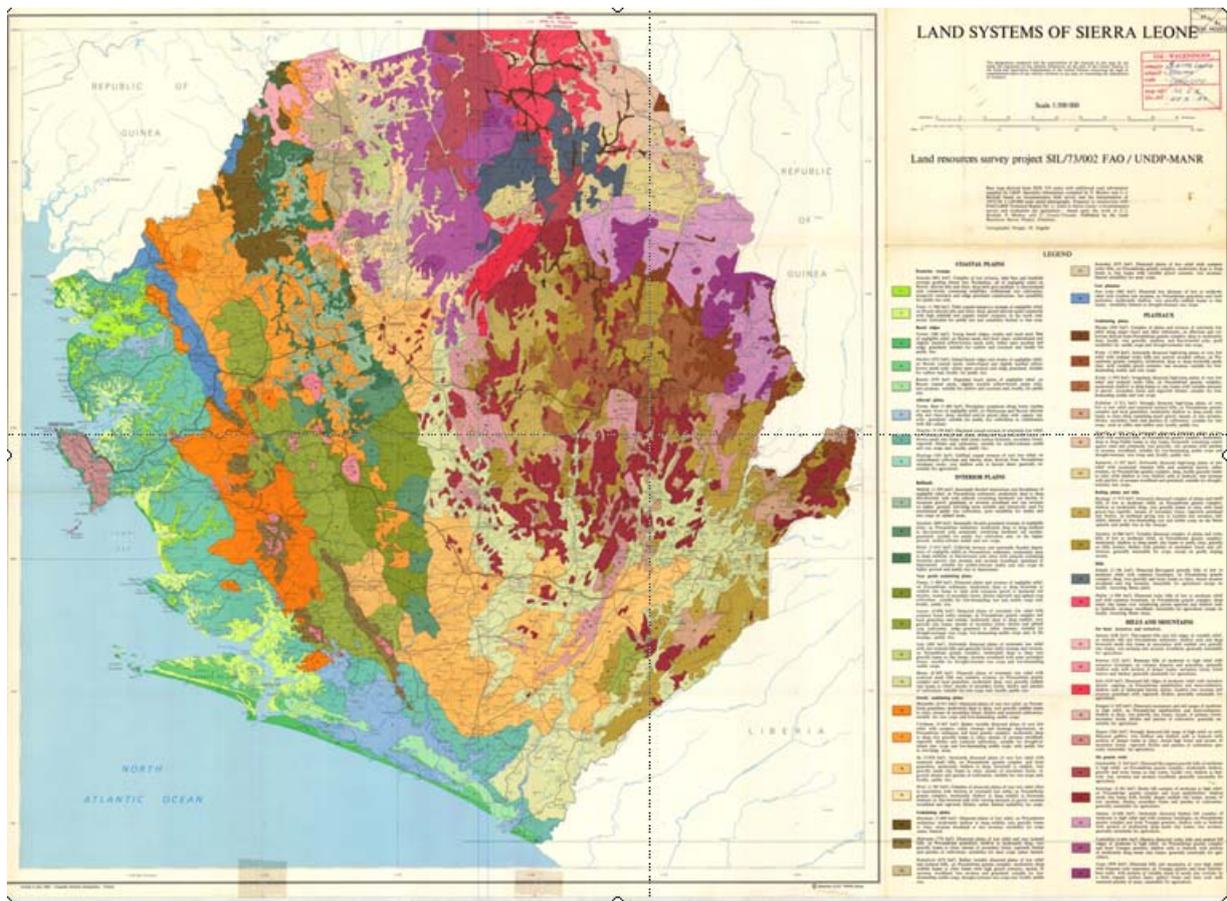
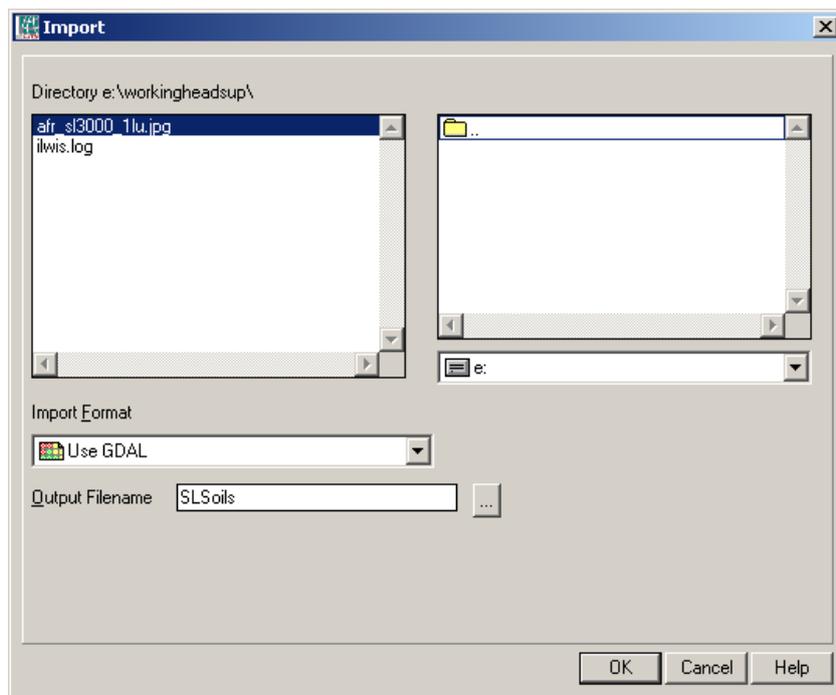


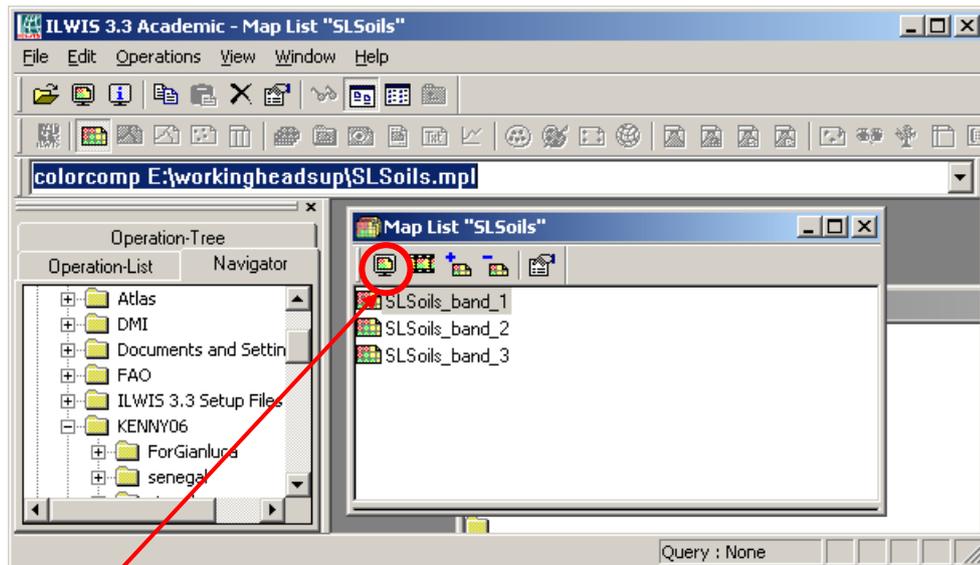
Figure 2. Scanned Map to be georeferenced in ILWIS

- Create a local directory on your workstation and copy across the lab data (see Table 1) from `.../dataforheasupdigitizing/..`

5. Start ILWIS (*Start → Programs → ILWIS 3.3*). Once ILWIS opens, navigate to your local directory where you stored the lab data.
6. From under the *File* tab, select *Import → via GDAL*. Select our scanned image *afr_sl3000_1lu.jpg* and call your Output Filename *SLSoils* (as below). This is a very big file give it time to import. GDAL is a GIS Open Source raster data translator. For more information about GDAL see <http://www.gdal.org/>.

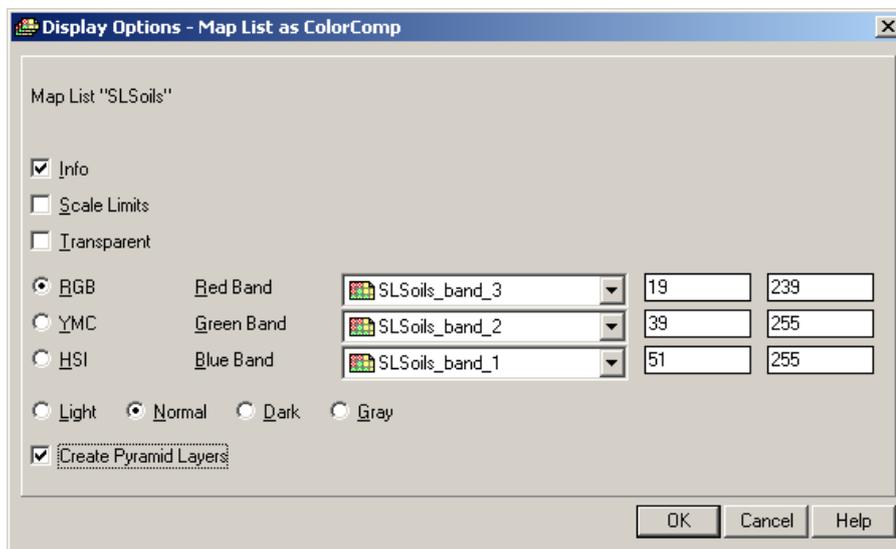


7. You may recognize the *.jpg* extension as a common image extension. This file contains 7974 pixels by 5887 lines yet only occupies 6.3 MBytes. Jpeg is a compressed image format and it appears these data are compressed approximately at a ratio of 20:1. In an uncompressed format these data would occupy approximately 140 Mbytes! This is an appropriate application of the *.jpg* formats. But because *.jpg* format does result in the loss of information and resampling, it is not generally appropriate for use with calibrated remotely sensed imagery or thematic raster data.
8. You will notice that ILWIS has translated this *.jpg* into three colour (R/G/B) separates called *SLSoils_band1*, *SLSoils_band2* and *SLSoils_band3* and a R/G/B colour composite called *SLSoils*. Double-click on *SLSoils* and in the following window from the Toolbar select the *Open As ColorComposite* option.



Open As ColorComposite.

- This will bring up the following window, accept the defaults. Select the **Create Pyramid Layers** (the practical reason for this will be covered later in the course). Creating Pyramids is a bit of up-front processing and uses extra disk space but will save you time in the long-run.



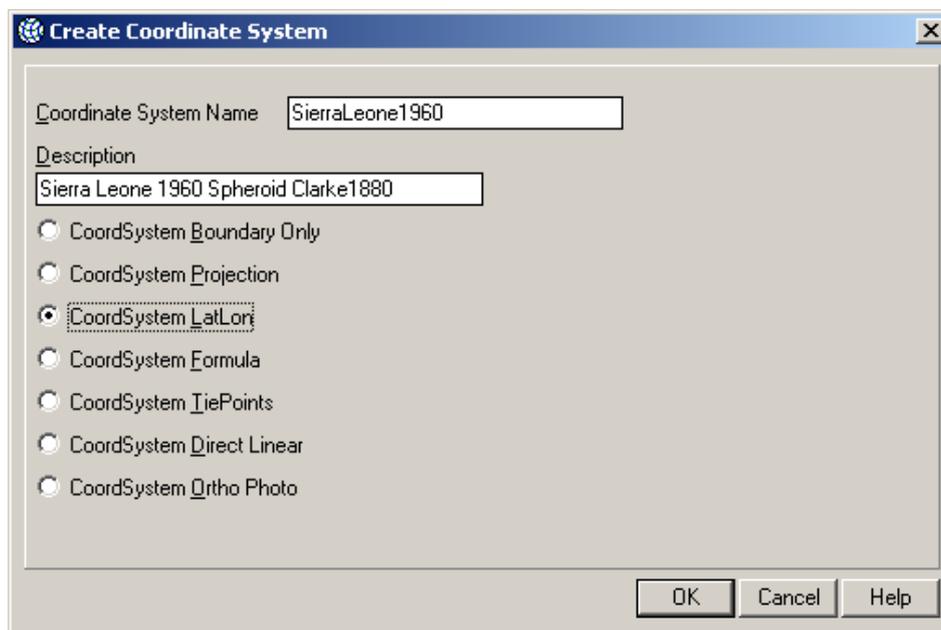
- This will open your scanned map in a separate Map Window. Take some time to Roam, Zoom and Pan to explore this Map, the Map Legend and the Map Surround. You will note at in the bottom right-hand corner of your screen it is indicted this map has **No Coordinates**. This is what we are about to change!

11. The next thing we have to do is create a *Coordinate System* consistent with this Hard-copy map. Through some digging it appears the *Coordinate System* for this map is as follows.

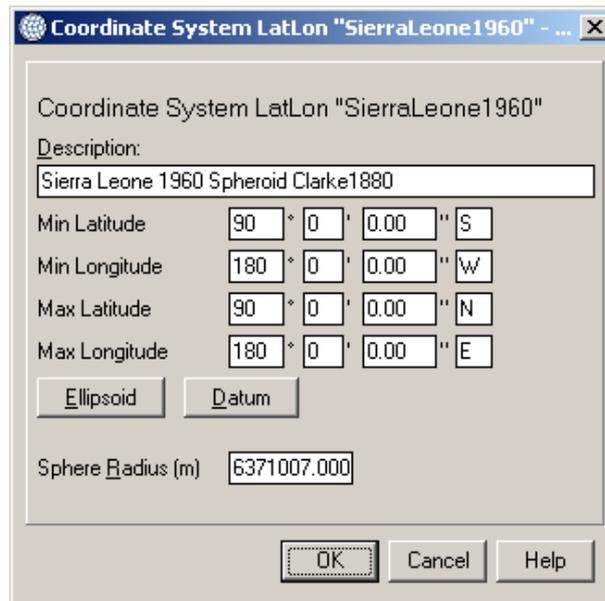
Coordinate System:	Longitude and Latitude
Spheroid:	Clarke 1880 (Modified)
Meridian of Origin:	9 West of Greenwich
Latitude of Origin:	Equator
Datum:	Sierra Leone 1960

This information was not found on this particular map. This map does however reference the base mapping used (Basemap D.O.S. 719/619 Series) and from another Sierra Leonian map at the JRC website the Spheroid/Datum was as described above. Sometimes it takes a bit of detective work. The spheroid referenced here is also consistent with this age of map.

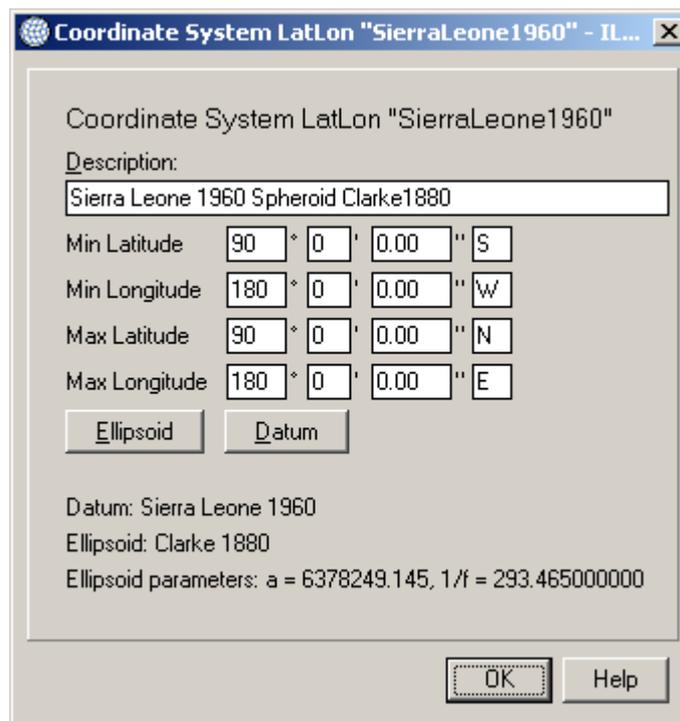
12. Through the next few screens, we will replicate this information for ILWIS to understand (don't worry about all the details!). At the main ILWIS window, from under the *File* tab select Create → *Coordinate System...* which will initiate the following window (see below). Enter the *Coordinate System Name* and *Description* as follows. Also select the *CoordSystem LatLon* option, followed by *OK*.



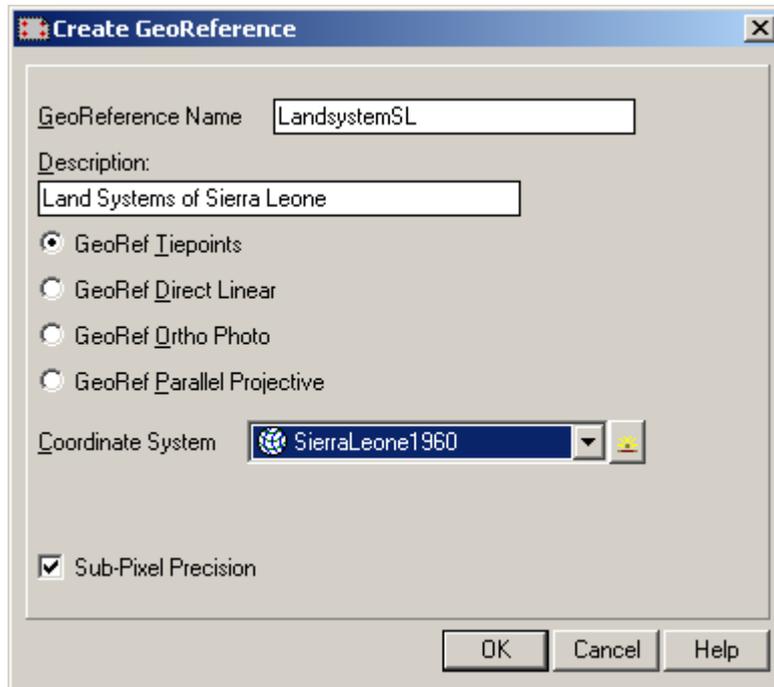
13. This will bring you to the following window. Select the *Datum* button.



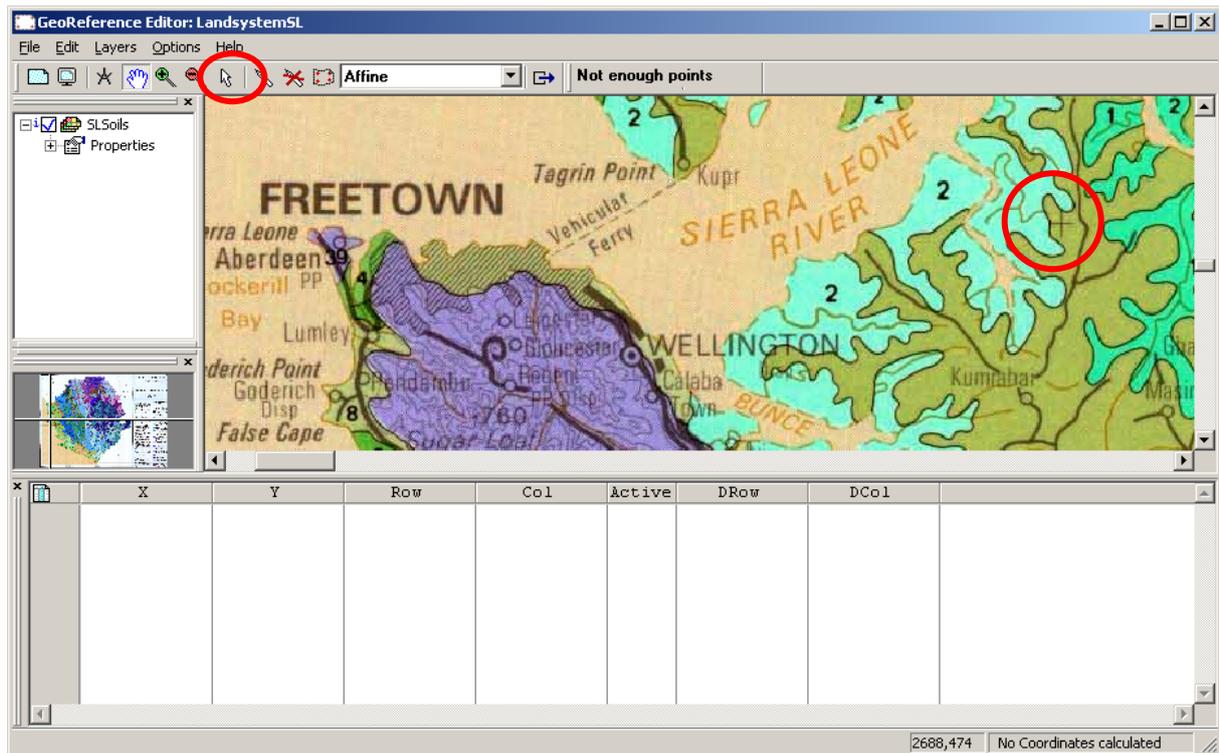
14. And from the predefined list select **Sierra Leone 1960** (just as our metadata says!). Now you have a fully created Coordinate System consistent with your scanned hard-copy map. Select **OK**.



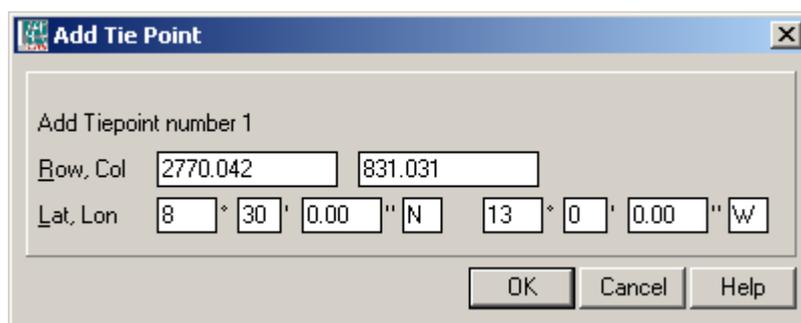
15. Now we will apply this Coordinate System to our map. At your Map Window, from under the **File** tab, select Create → **GeoReference**. This will initiate the following window requiring your input.



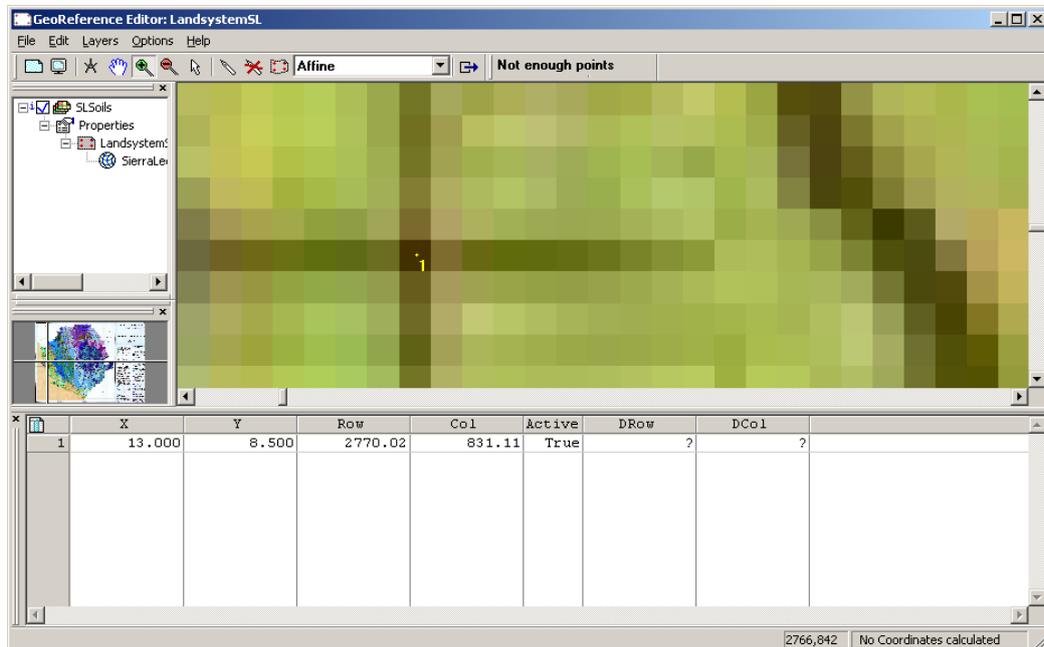
16. The **GeoReference** as we saw in your Raster Lab this morning carries your corner coordinates, pixel size and has embedded the **Coordinate System**. As shown above, call your **GeoReference, LandsystemSL**. Select the **GeoRef Tiejoints** option and beside Coordinate System, click the down-arrow and select our just created **SierraLeone1960** Coordinate System. Also select the **Sub-Pixel Precision** option. This will initiate the **GeoReference Editor** as shown below. The objective here is through user specified “**Tie Points**” (or Ground Control Points) to bring this spatially uncorrected map to a map with earth coordinates. You should be warned before you begin that this process the first few times through can be quite frustrating!



17. Use the Zoom, Pan and Roam functions to find a location on the map where the Geographic Coordinates (Longitude and Latitude) can be easily identified. This is a very good map with many easily identifiable locations. The best locations are along the map edges or where you see cross-hairs (as above in a red circle) indicating intersecting Longitude and Latitude values. The intersection shown here is 8deg30sec North and 13deg West. It is through identifying these points in the lower window we will be able to completely georeference the entire map. Zoom right into your identified point, and with the **Normal Pointer** (as above) click on the identified point. This will bring-up a new menu for you.



18. This window has identified the local map Row and Column coordinates and you must enter the Longitude and Latitude for the identified point (as above). To do an accurate job, you have to zoom quite far into the image to the point you can identify individual pixels (as below).



19. Continue this process through your image and collect a well distributed pattern of “Tie Points”. Collect at least 20 point – more is always better. Note the Tie Point table in the lower half of your screen is like any other table in ILWIS - you can add points, delete points, etc. Also note in the table the DRow and DCol are estimates per point of error (measured in pixels) for each selected point.

20. Once you have collected a certain amount of points, in the bottom right-hand corner your system will start to display earth coordinates. At this point you can even add vector layers onto your map. Continue to collect points till you have a good registration of your map. Once satisfied with your registration (or had enough for a day!), select the *Exit Editor* button on the tool bar and ILWIS will automatically save your *GeoReference*. Before exiting, ensure that you selected a “*Full 2nd Order*” for transformation (as in the figure below). This full second order polynomial will best accommodate any scanning errors introduced or hardcopy map distortions. Once you leave the editing environment you can not change the order of the polynomial transformation.

True Longitude and Latitude Coordinates
 Vmap(0) Roads Overlain

GeoReference Editor: vmap(0) roads

File Edit Layers Options Help

Full Second Order

Sigma = 1.637 pixels

X	Y	Row	Col	Active	DRow	DCol
5	-10.500	1028.98	5154.98	True	1.40	-0.87
6	-10.500	1897.05	5157.99	True	-0.51	-1.34
7	-12.000	157.06	2564.99	True	-1.74	1.63
8	-10.250	2766.01	5598.02	True	-1.20	2.41
9	-13.000	1031.01	836.05	True	-0.18	0.45
10	-12.500	1032.09	1698.09	True	2.10	-1.59
11	-13.000	3639.17	828.13	True	-0.39	0.29

2525,706 8°38'29.2"N, 13°04'20.19"W 8°38'29.18"N, 13°04'20.19"W

To Change Transformation (Note you should not require more than Full Second Order)

To exit Editor

Estimate of error (in pixels) in X and Y

Overall Estimate of fit to the selected Polynomial

21. Once you exit the editor, ILWIS will “on-the-fly” calculate earth coordinates for any location within the image/map. You can actually digitize fully georeferenced segments or points directly from this map if desired. In our case however we are going to permanently resample this map to a Geographic Coordinates System (Datum WGS84) to make this map consistent with our other data sets. Resampling the map will also enable you to utilize this map within other GIS software.
22. If you want to return to add more tie-points at any time you can reinitiate your editing session from under the *Edit* tab → GeoReference and continue directly from where you finished.
23. With at least 20 well distributed tie-points and with an overall registration estimate of less than one or two pixel, you are ready to **RESAMPLE** the image/map.
24. From under the *Operations* tab of Main ILWIS menu, select *Image Processing* → *Resample*. This will initiate the following series windows. In the first window (called *Resample Map*) select your input map *SLSOILS*. Select a *BiCubic* Resampling Method (as below) and call your *Output Raster Map: soilsgeo* (as below). We are not quite finished with this window yet.
25. We must also create a new *GeoReference* for our new map – *soilsgeo*, so select the create icon beside *GeoReference*. This will subsequently initiate another window, (also shown below) that describes a selected Coordinate System (select LatLongWGS84 from the pull-down menu), Coordinate Extents in Lat and long and Pixel Size (in degrees, minutes and seconds) of the new map – *soilsgeo*. Select the parameters for this window as shown below, followed by **OK**.
26. Your Resampling is now ready to be conducted. At the *Resample Map* window, select the **Show** option. This will both resample the map and display the finished results for you.
27. This is a very intensive computer processing task and it may take some time complete. Once it has successfully run to completion, examine your fully georeferenced map.

Resample Map

Raster Map:

GeoReference TiePoints "LandsystemSL"

Value Range: Minimum: 0 Maximum: 255

Resampling Method

Nearest Neighbour
 Bilinear
 Bicubic

Output Raster Map:

GeoReference:

Sierra Leone in Geographic (WGS1984)

Value Range:

Precision:

Description:

Create GeoReference

GeoReference Name:

Description:

Coordinate System:

Pixel size: * * "

MinLatLon: * * " N * * " W

MaxLatLon: * * " N * * " W

Center of Corner pixels

5702 lines and 5701 columns

28. What we have accomplished here is the first and required stage for “Heads-Up” digitizing. The next stage is to actually digitize features on screen and the resultant segments, points and polygons will have true earth coordinates.
29. Note the next lab - ***Heads-up Digitizing from Scanned Hard-Copy Maps, Part II*** continues directly from this lab utilizing the map *soilsgeo* that you just created.