

**Ministry of Lands and Natural Resources
The Republic of Ghana**

**Participatory Forest Resource Management Project
in the Transitional Zone
(PAFORM)**

**Participatory Approaches for
Forest Reserve Management
PAFORM Approach and toward its Wide-use**

**ANNEX 2
Technical Manual on How Effectively Apply GIS
Techniques for Forest Management Planning**

January 2009

**JAPAN INTERNATIONAL COOPERATION AGENCY
Sanyu Consultants Inc.**

GNO

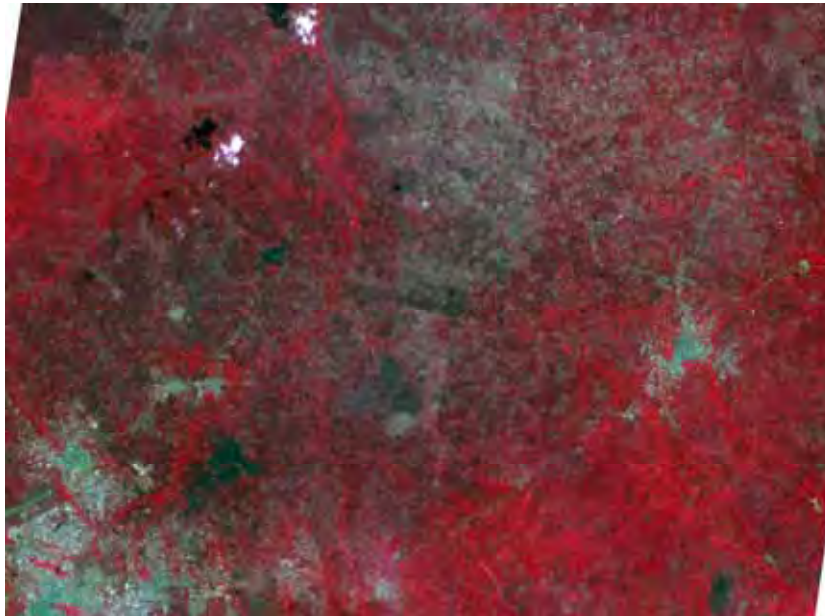
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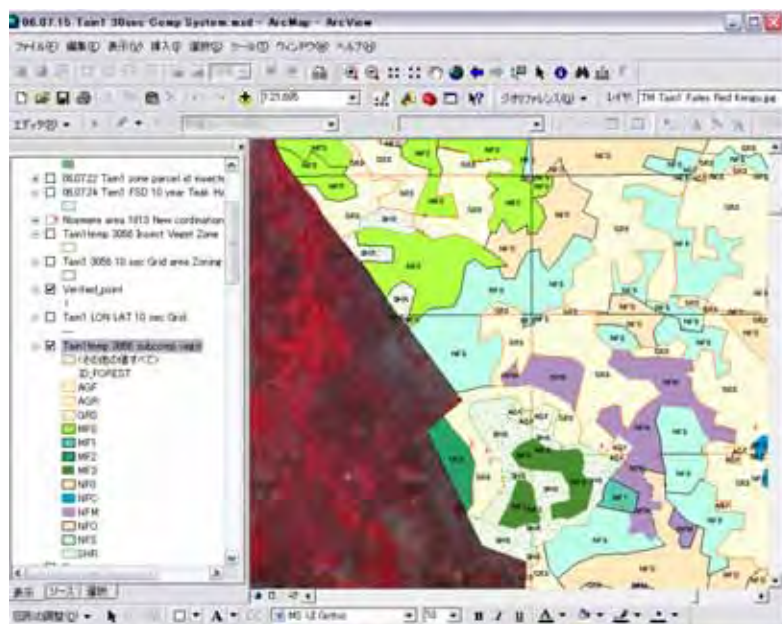
GIS Manual

for OJT on

How effectively apply the GIS techniques for Forest Management Planning, Sunyani Ghana



Aster Sample on Tain 1 forest reserve



January 2009

Foreward

This manual is prepared for On the Job Training (OJT) for FSD staff how to use GIS for forest management planning purpose. Therefore, the manual is not covered full functions of Esri Arc Map and Arc Catalog. The explanations are concentrated functions needed for vegetation or forest type map making.

In generally, to obtain digitized topographic map that is defined coordination system (longitude and Latitude) is quite difficult in Ghana now. And to make these map by mapping company needed high price burden. This manual is introducing a simple and practical way for getting digitizing base map using Land Sat TM (satellite). The picture of Land Sat TM that was shot on several years ago is provided by Maryland University (USA) on Internet free of charges.

For the vegetation analysis the manual proposed to use picture by Aster (name of Satellite 10m x 10m pic-cell).

The manual explained step by step basis from base digital map making, to make vector maps(digitized map) from existed maps printed on papers, how to make new layers for different polygons stored, how to give identifying cords to data tables, etc.. And finally to print out a forest management plan maps that shows harvesting plan, planting plan, community involvement plan, etc.

The OJT participants are requested to get GIS operational knowledge and experiences through practices how to operate the GIS software (Arc View : Esri) using own personal computer. To obtain the skills, OJT participants are requested to face difficulties, to make miss operations, then it is most important to consider why the computer was not worked that the OJT participant had expected and find solutions by themselves.

This manual is expecting to help the OJT participants for understanding the demonstrated operation within the OJT by Mr. Miyazaki.

The author believes, that the OJT participants can find some kind of solutions when he or she made miss operation to review this manual and develop their capability if the participant can bear patient works for delineating vegetation type demarcation, and its bags clearing, miss conducted features amendment and as well as field observation and verification with strong motivation for the development of the Ghanaian forest management planning measures.

June 2007

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JICA Expert for PAFORM

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Section 1 Flow of the works

(1) Outline of the works for making vegetation map using GIS

The procedure of the work is following

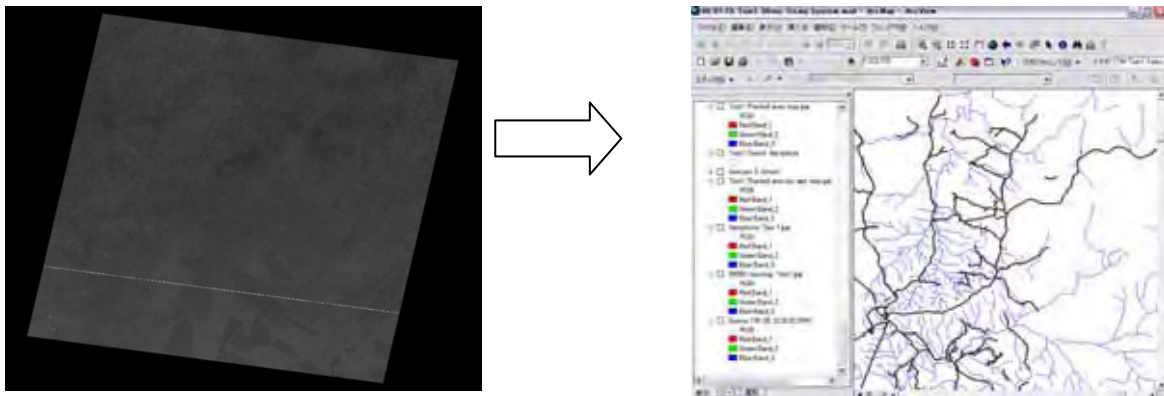
1) Base map preparation

a. Download Satellite TM data from Internet for the target are, and decompress the data to Geo- Tiff format.



b. Put the Geo-tiff satellite imagery to Arc map

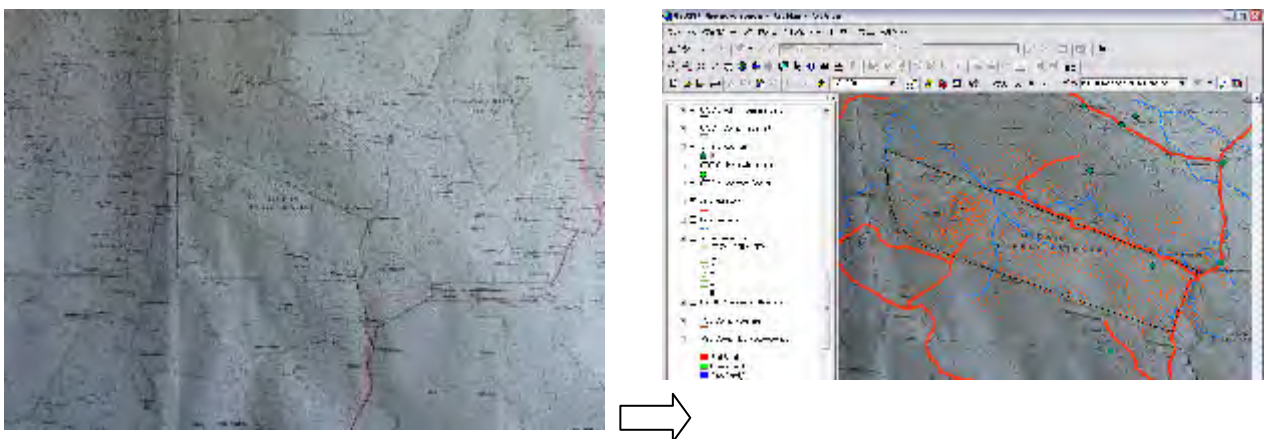
c. Trace the river line and other typical landmarks as digital shape and make digital base map.



2) Add needed topographic information from 1/50,000 paper map to Arc Map

a. Scan a topographic map surrounded the target area for Luster data, and put the data to Arc map

b. Arrange the topographic map just fit on the base map made above c.



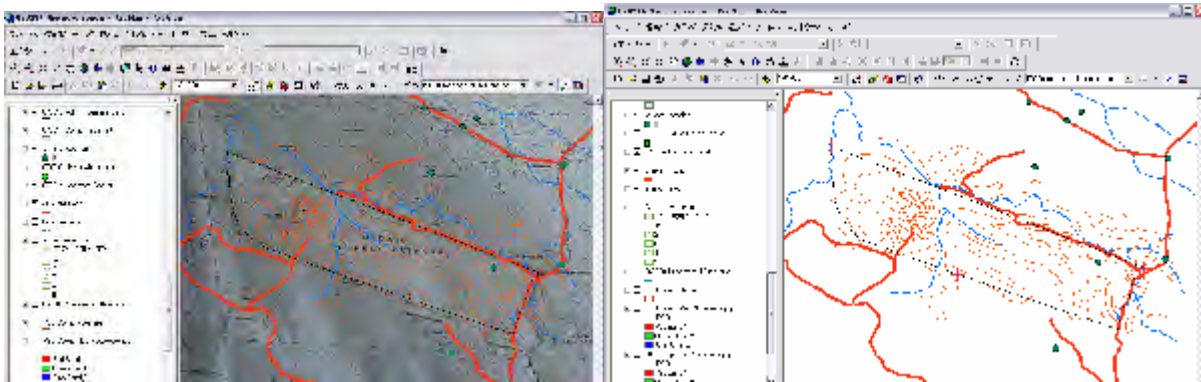
(Red line shows road and blue line shows river on the digital base map, Nsemere area had traced from 1/50,000 topographic map to GIS map as a new layer named “Admi area Nsemere”)

Also traced villages location in dark green point mark, contour lines on dark orange color.



f. Trace adjusted topography map needed information such as location of villages, un identified roads from the Satellite TM, land marks (such as mining site, factory, etc.) on new layer shape file on the Arc Map.

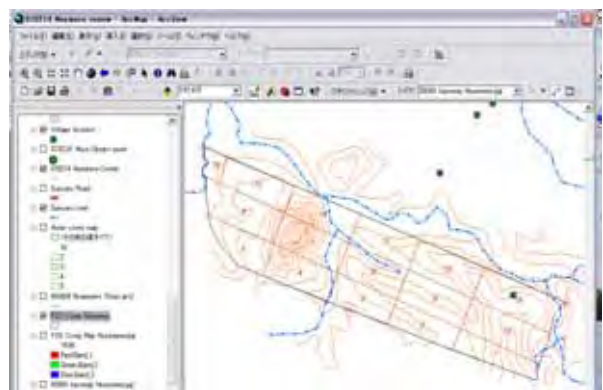
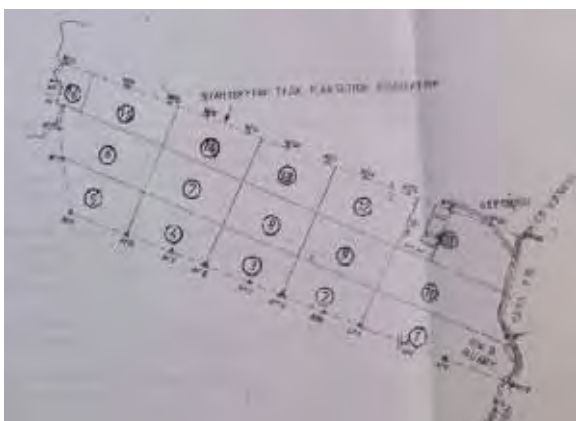
g. Trace boundary line/shape on the adjusted topographic map to a new layer as “XX area forest reserve”.



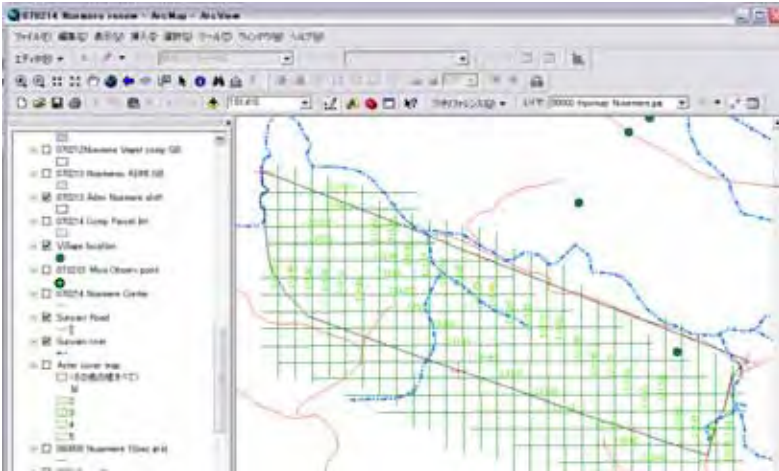
Trace topographic map for digitalizing the map information for new layer shape files.

3) Set a compartment system based on Longitude and Latitude for smooth identification the boundary lines of a compartment on the ground. (10 seconds square unit as a parcel for plantation activity management in the field.

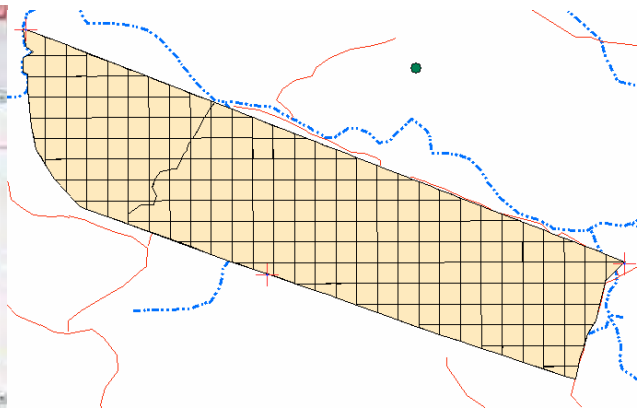
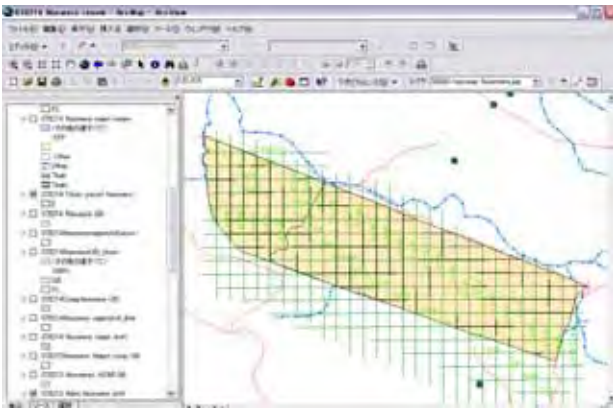
a. Establish FSD exiting compartment system on Arc Map.



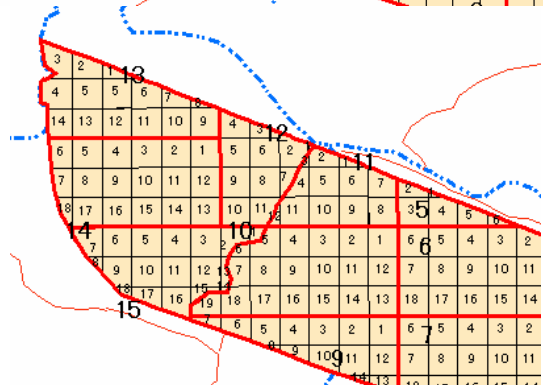
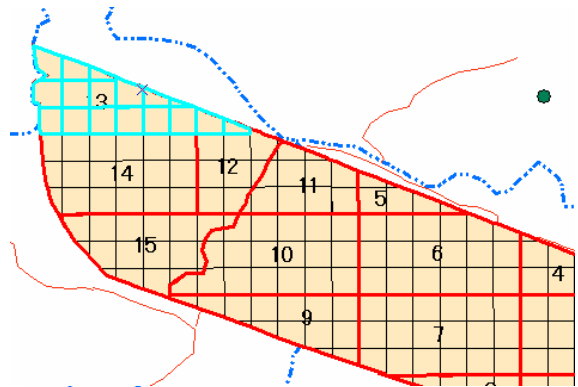
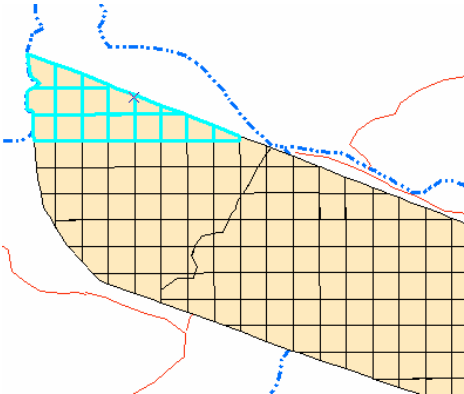
b. Make lines for 10 seconds interval both Longitude and latitude on Arc map.



c. Divide the administration area into 10 sec unit tracing Longitude and Latitude line for 10 second units parcel map.



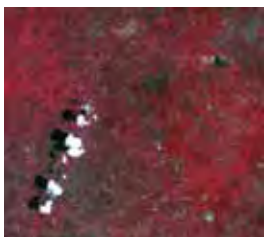
d. Merge parcels in to compartment.



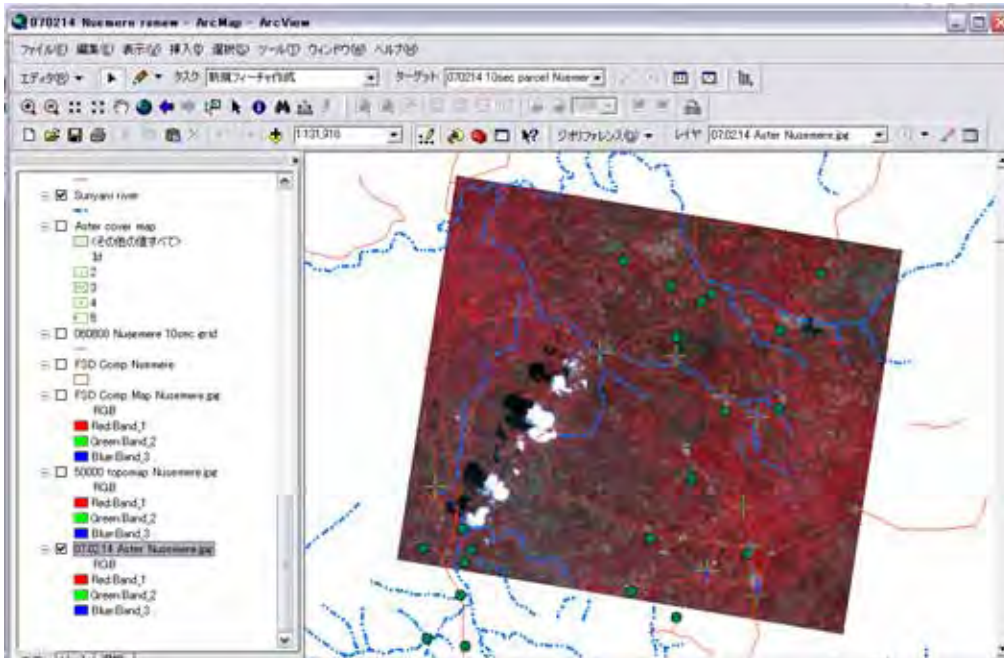
And gives to each polygon for compartment Number.

e. Give a number to each parcel.

4) Vegetation/Forest type map making with Satellite Imagery Aster.



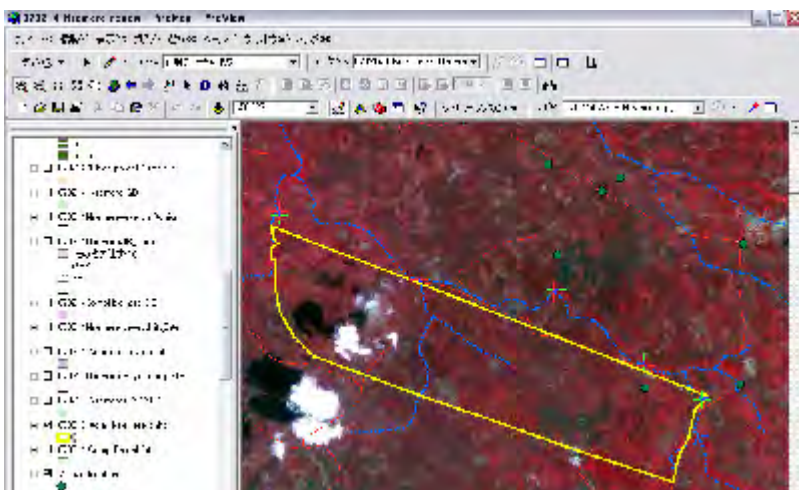
a. Aster image covered the target area shall be put on the Arc Map.



b. To adjust the image positions to Base map.

c. Prepare a polygon shape layer for vegetation demarcation named as “Nsemere veget”.

Copy Nsemere administration polygon to a new layer “Nsemere veget” above.

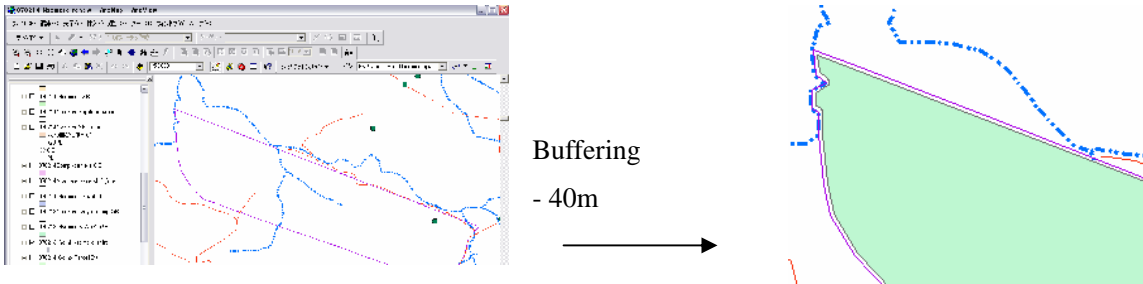


d. Divide Vegetation polygon in to different color patterned areas for temporally vegetation map, and give legenda to each vegetation type.

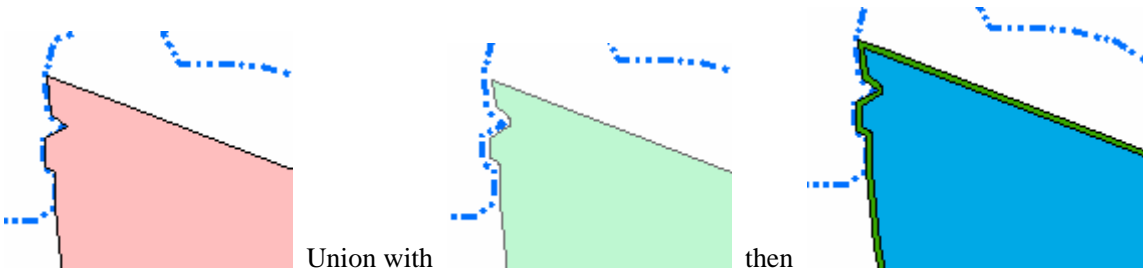
5) Green Belt area setting (Buffering).

Green belt shall be set on inside 40m from outer boundary for community participated forest reserve protection.

- a. Select “Nsemere administration” polygon, and do buffering command from -40m., a layer excepted 40m area (Green Belt area) polygon layer is automatically made (named such as “Nsemere Plantation area”).

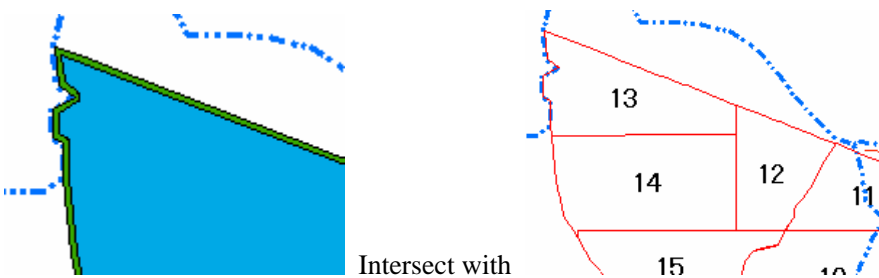


- b. Intersect “Nsemere administration” and “Nsemere Plantation area” using Geo-processing command. Then a new layer named “Nsemere GB and PL area” consists Green Belt area, and plantation area polygons on a layer. Then give the identifying cord GB and PL for each polygon on data table.

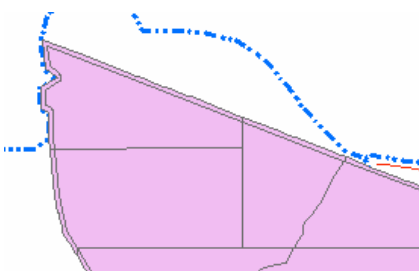


6) Every Compartment area shall be divided into Green Belt area and Plantation area.

- a. Intersect Compartment layer and Nsemere GB and PL area layer using Geo-processing command. Then a new layer shows divided each compartment into Green Belt area and Plantation area.



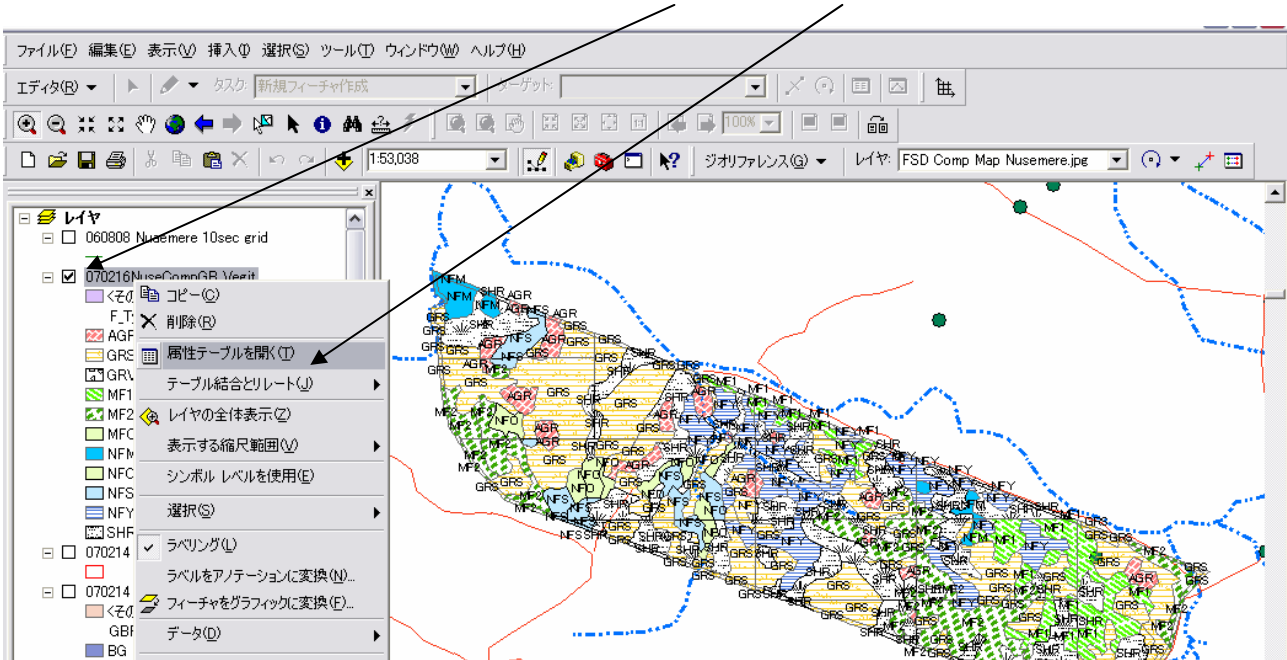
Then Green Belt area and Plantation area are divided into compartment.



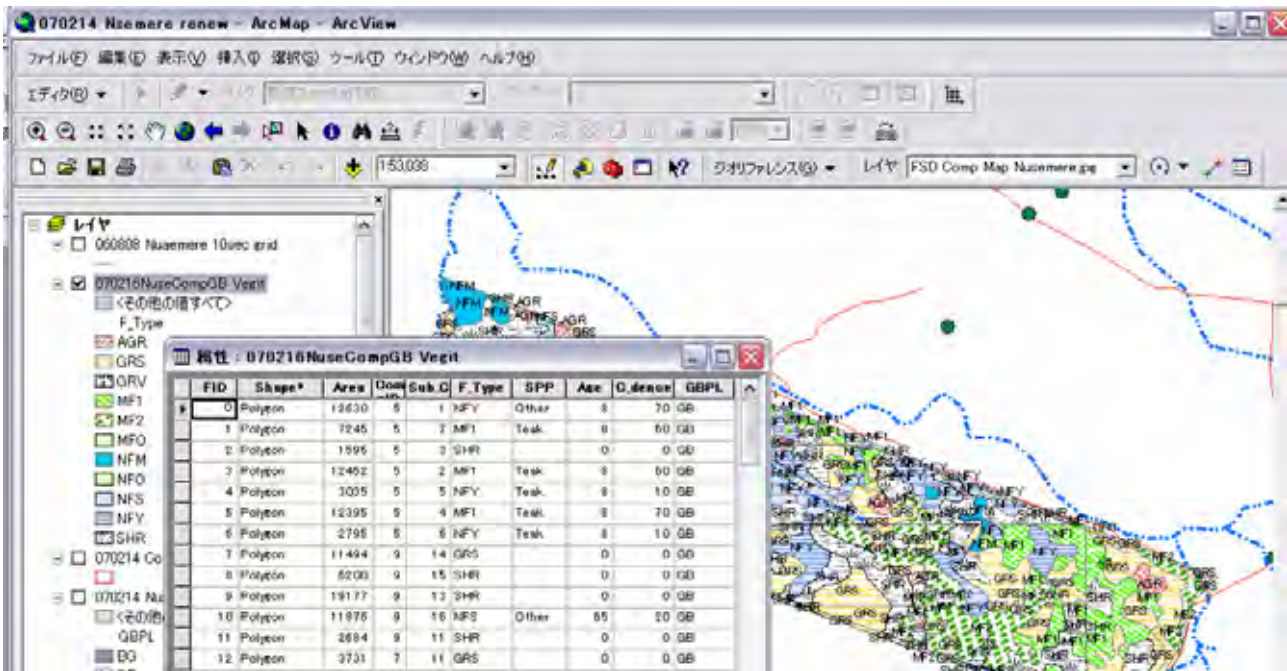
=

(2) Preparation of Forest Inventory book and totaling the forest condition of Nsemere Forest reserve.

a. Fill the related data for forest type such as age/planted year, crown density, planted species, etc into every fields of the database table. These data shall be prepared by the FSD as stocked records, paper maps, explanations, and surveyor’s own field observations and surveys.

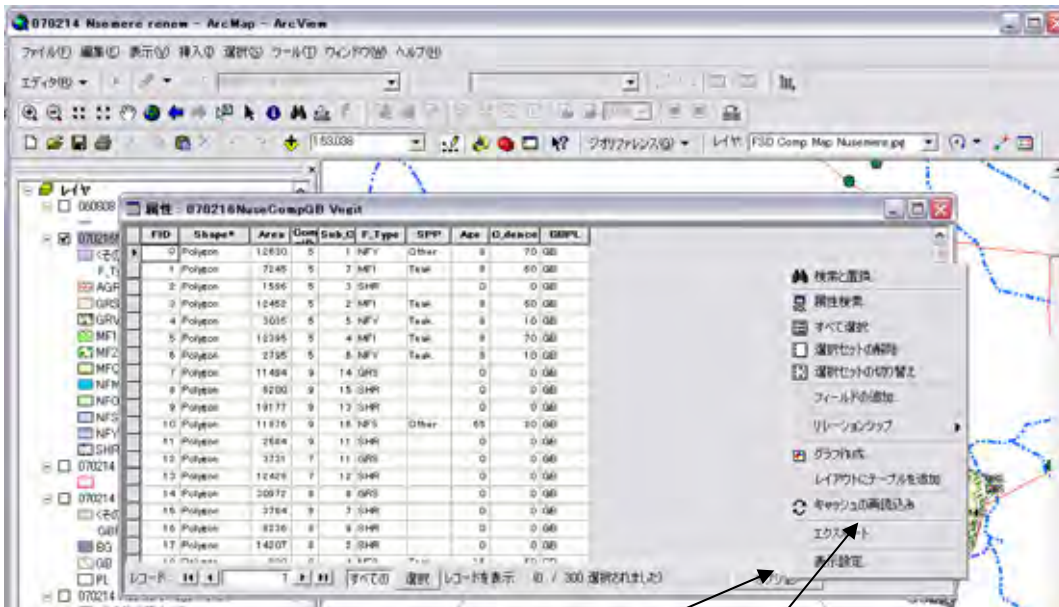


Open the Data table of the layer for Vegetation with Green Belt.



Fill the fields (columns) Forest type code (F type), Age of the planted forest, Species, and Crown density.

b. Export the table in Arc map vegetation and compartment layer as a text file format, and then, read by Excel. Totaling work shall carry using Excel function “Pivot table making”.



Read the exported Text file by Excel (results are following).

	0	Comp	Sub_C	Area	Ha	F_Type	SPP	Age	C_dence	GBPL	Area m^2
1	90	5	1	1.26	NFY	Other	8	70	GB		12630
2	102	5	7	0.72	MF1	Teak	8	60	GB		7245
3	94	5	3	0.16	SHR		0	0	GB		1596
4	92	5	2	1.25	MF1	Teak	8	60	GB		12452
5	98	5	5	0.30	NFY	Teak	8	10	GB		3035
6	96	5	4	1.24	MF1	Teak	8	70	GB		12395
7	100	5	6	0.28	NFY	Teak	8	10	GB		2795
8	192	9	14	1.15	GRS		0	0	GB		11494
9	194	9	15	0.62	SHR		0	0	GB		6200
10	190	9	13	1.92	SHR		0	0	GB		19177
11	196	9	16	1.19	NFS	Other	65	20	GB		11876
12	186	9	11	0.27	SHR		0	0	GB		2684

c. Arrange the excel table to meet general form of the Forest Inventory Book.

Forest Inventory Book Tain 1 revised to meet Green Belt Feb.10 2007 from A										
No	ID	Comp	Sub	Area	Ha	Forest Type	Species	Age	Crown Dencity	Plant or Green belt
1	1	1	1	1.59		GRS		0	0	GB
2	1	1	1	0.53		GRS		0	0	PL
3	1	2	2	6.01		MF2	Teak	17	80	GB
4	1	2	2	17.09		MF2	Teak	17	80	PL
5	1	3	3	3.81		GRS		0	0	GB
6	1	3	3	39.86		GRS		0	0	PL
7	1	4	4	1.67		GRS		0	0	GB
8	1	4	4	3.32		GRS		0	0	PL
9	1	5	5	0.16		MF1	Teak	12	60	GB
10	1	5	5	44.23		MF1	Teak	12	60	PL
11	1	6	6	8.03		AGR		0	0	PL
12	1	7	7	4.86		MF1	Teak	8	65	PL
13	1	8	8	8.55		SHR		0	0	PL
14	1	9	9	9.90		GRS		0	0	PL
15	1	10	10	1.20		SHR		0	0	PL
16	1	11	11	0.93		GRS		0	0	GB
17	1	11	11	30.92		GRS		0	0	PL
18	1	12	12	13.37		SHR		0	0	PL
19	1	13	13	5.57		GRS		0	0	PL
20	1	14	14	1.81		SHR		0	0	GB
21	1	14	14	8.46		SHR		0	0	PL
22	1	15	15	3.78		GRS		0	0	PL
23	1	16	16	0.84		MF1	Teak	8	60	GB
24	1	16	16	0.92		MF1	Teak	8	60	PL
Compartment total				217.41						

Then you can start forest management planning to fix harvesting areas and periods, needed reforestation areas for planting plan, and other factors to insert Arc map such as preservation forest ecological condition for maintaining bio-diversity, areas for traditional villagers spiritual forest reserve (except from harvesting targets), etc.

The measures how to operate Arc Map functions are explained from next sections.

Section 2 Details of the operation Arc GIS

Sub-Section A Preparation a digital map for GIS base map as defined Longitude , Latitude

1. Download a Satellite TM data from Maryland UNV USA

If you haven't digital map (vector data/shape files as defined the location by Latitude and Longitude), you have to make these Base map by yourself using satellite imagery. A satellite image by land-sat can get in free from Maryland University Home page Global Land Cover Facility (Copyright © 1997-2007 University of Maryland) .



(Address of the internet is “<http://glcf.umiacs.umd.edu/index.shtml>”)

Use Google search “GLCF”, you can find download service page. Follow the instruction on the page. You can select a Land sat TM or ETM data where a area you want to analyze. Then you can down load data files from Band 01 to 07 in compressed pattern (zip). The down road had finished, you have to defrost the file.

Note: NOAH (name of free use soft for compress and decompress) can use for defrost that you can get this soft from internet.)

Note: Even the compressed file the size is exceeded 30,000 k bites. It means if you cold not use ADSL it needs several hours for only 1 picture data.

The satellite data are not new but effective for preparation digital base map for GIS

One example downloads files on Sunyani Ghana

p194r056_7k20020115_z30_nn62.tif.gz

p194r056_7t20020115_z30_nn10.tif.gz

p194r056_7t20020115_z30_nn20.tif.gz

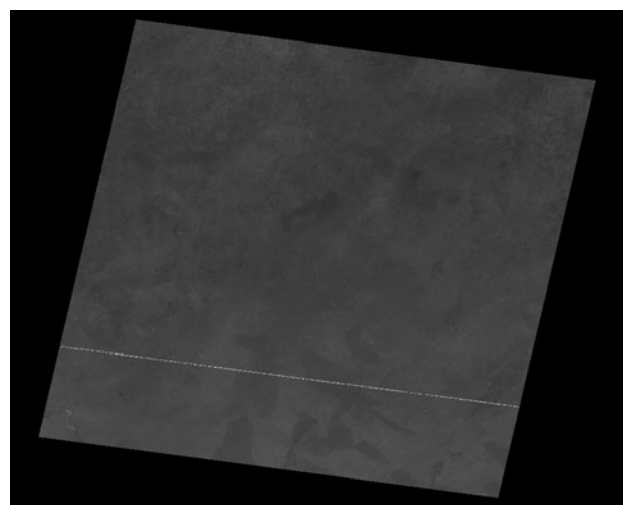
p194r056_7t20020115_z30_nn30.tif.gz

p194r056_7t20020115_z30_nn40.tif.gz

p194r056_7t20020115_z30_nn50.tif.gz

p194r056_7t20020115_z30_nn70.tif.gz

Defrost files samples



A sample TM B&W Band 4 2002.02.10

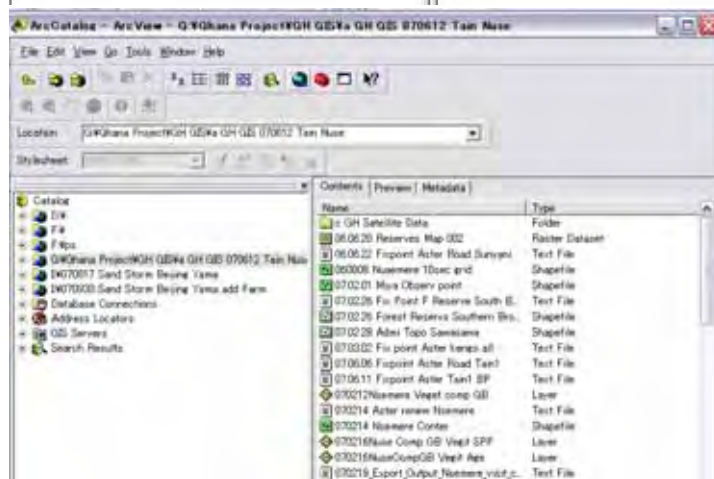
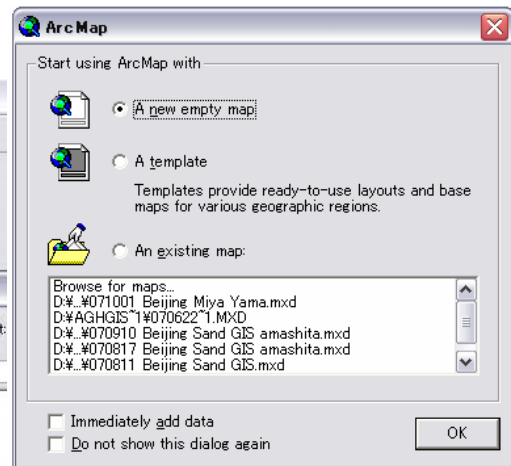
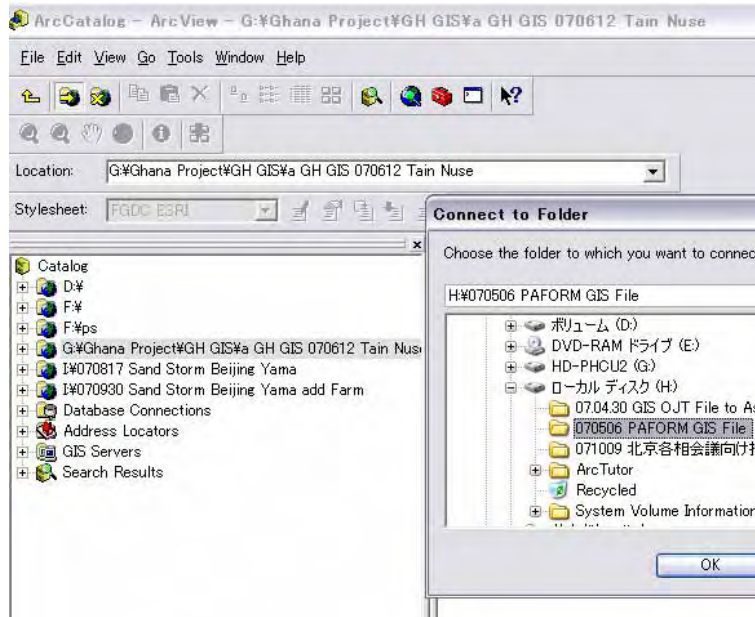
p194r056_7t20020115_z30_nn10.tif
 p194r056_7t20020115_z30_nn20.tif
 p194r056_7t20020115_z30_nn30.tif
 p194r056_7t20020115_z30_nn40.tif


2. Open GIS (Esri) and view satellite TM (raster data) on arc map GIS (Arc View 9.1)


a. Make a folder “Sunyani GIS 0207Jun (example)”, and store the files Satellite TM (defrosted as Gio-Tif format) files on your computer on route directory.

b. Open Arc Catalog and make link to c:/ Sunyani GIS 0207Jun.

Then file list will appear on the screen.



(i)  => select folder Sunyani GIS 0207Jun for establish relation a folder and Arc-catalog. Then the catalog view shows right side figure above.

(ii)  for open the arc map. Then a raster file (band 4) on catalog drag and put to map

(click and drag).

When a window for arc map opened you give mark to new map if you opened it at the first time, and if you had saved the map, you can call the map from the existed map file list.

If a window like right figure came, asking Pyramid Structures building, crick yes then computer make the file for describing patterns for map view. Then map with Land Sat TM image will come below (left).



To expand the map using



icon, you can identify rivers lines (right side figure).

To trace river lines, roads are the bases of the digital base map for analyzing later.

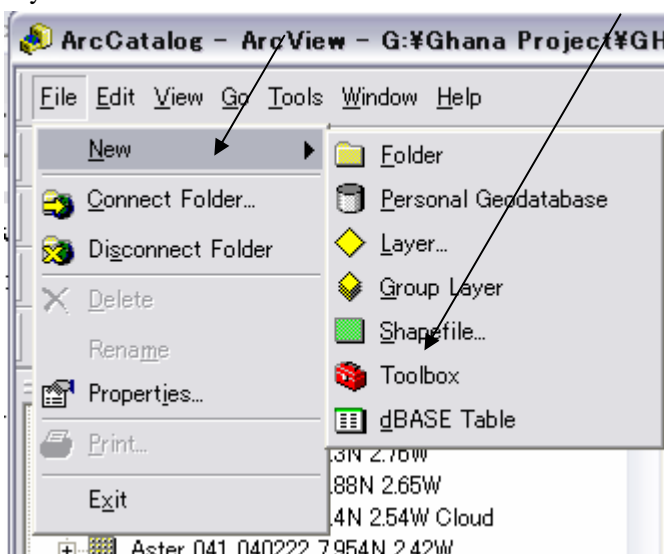
3. Making river line feature as Poly-line shape file (Layer) for arranging the digital base map

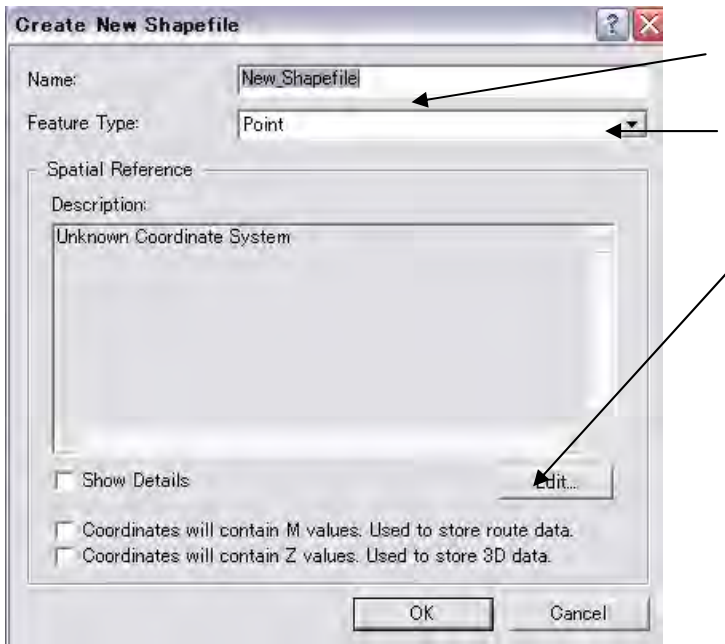
Why did we use Satellite picture for base map arrangement?, because the satellite data have the location data. The picture formatted Gio-Tiff (generally provided from NASA and other sources) can be used Geo-coordination for the new map. A paper map can be used, but the fixing location Longitude and Latitude on every corner of the paper map have to be cleared. The defining method for GIS arc view needs special knowledge, and not detailed explained on the official operating manual. The free satellite data provided by “GLCF” is not new (generally more than 5 yeas before captured), but main roads, big rivers are not moved in general. For the digital map fixing location making, the data is effective and easy way to use.

(1) Preparation a file for new shape.

Preparation a file for new shape such as “river sunyani” and “roadsunyani” using arc catalog.

Call Arc catalog view => crick File =
>crick new file => Select shape file





- Key in a file name "River sunyani".
- Select a type of shape file (Polygon, Point, Line). River sunyani is "Line".
- Import coordination system as below.

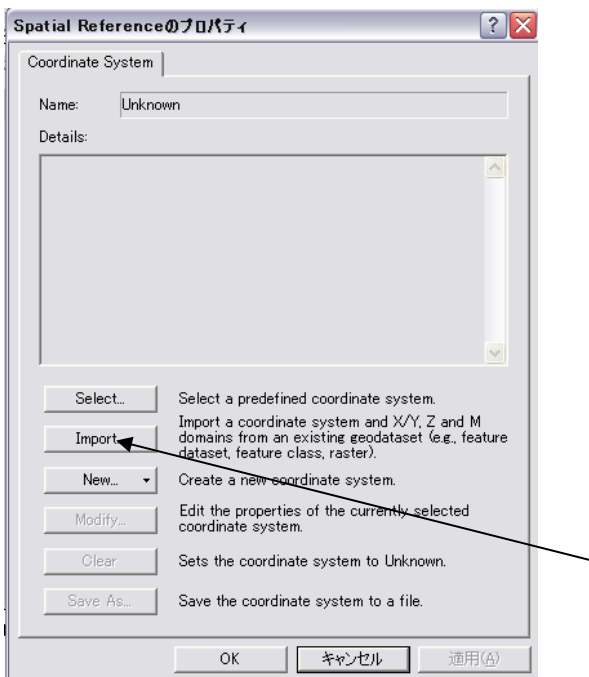
Click Edit button in the new shape window.

New window for coordination system definition as below left.

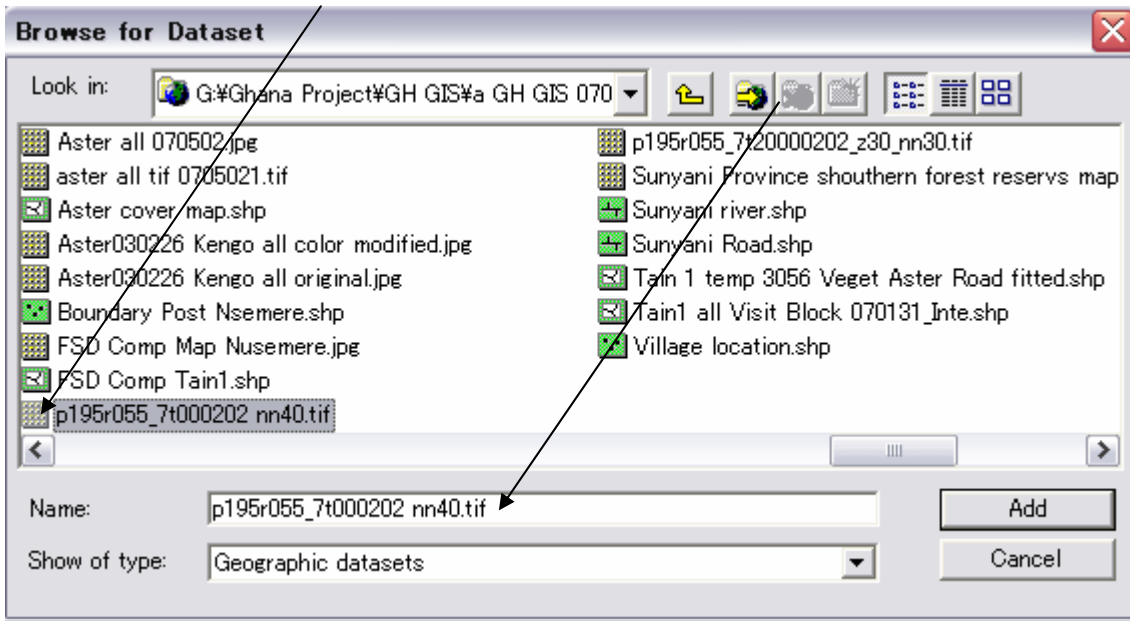
- Click import

The arc view request to define the coordination system same as a file existed. You have to select a file (The Land Sat satellite file that you put to the arc map (p195r055_7t20202 40).

- Then "OK".

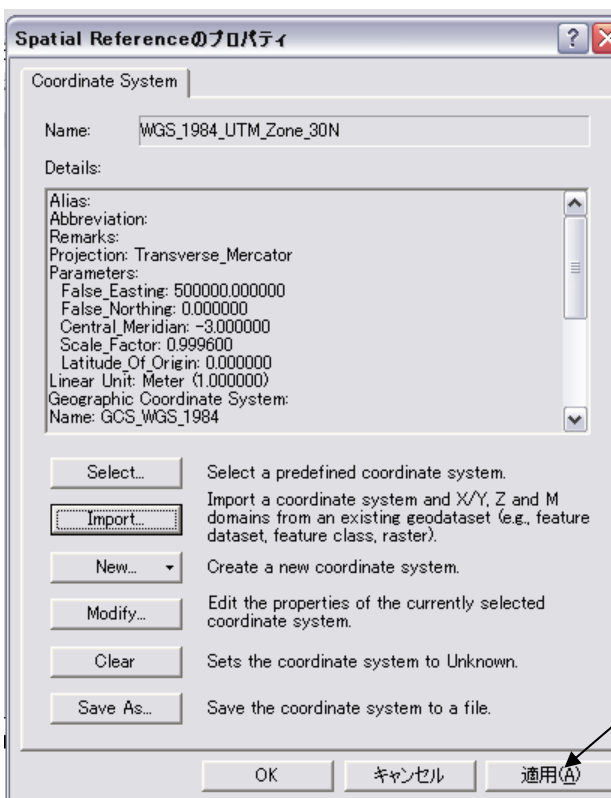


Select a file for coordination system definition same as satellite TM (p195r055_7t000202 nn40. tif) among the existed coordination defined file list.

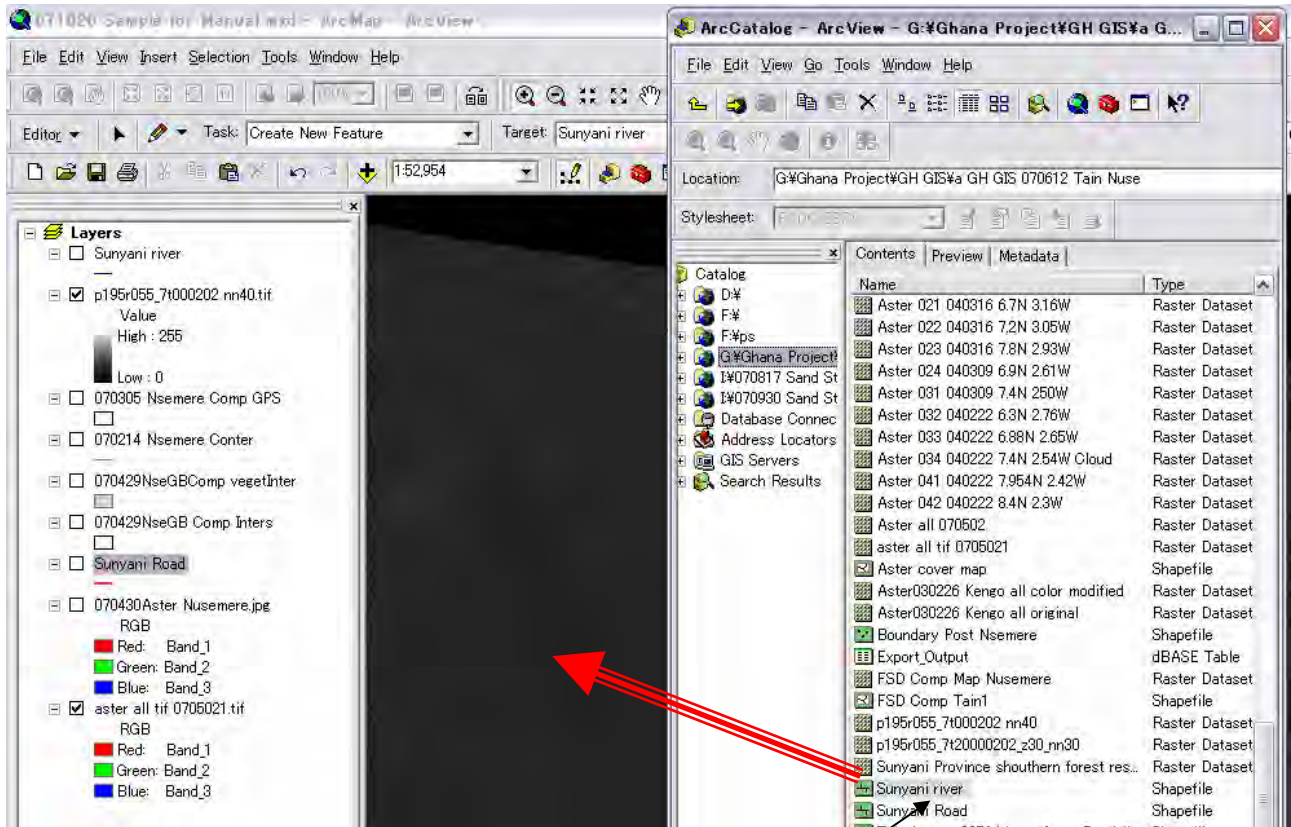


After clicking “add” a following window will come.

Then click “Apply”.



(2) The new file come on the arc catalog, you drag and drop the file to Arc Map.



Arc Map

Arc Catalog

A blank shape (line) had set on the Arc Map.

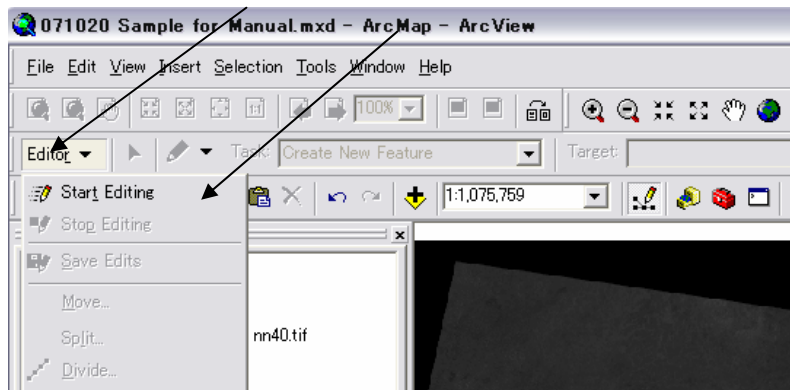
(3) Trace the river lines on “Sunyani river” .

Procedure follows.

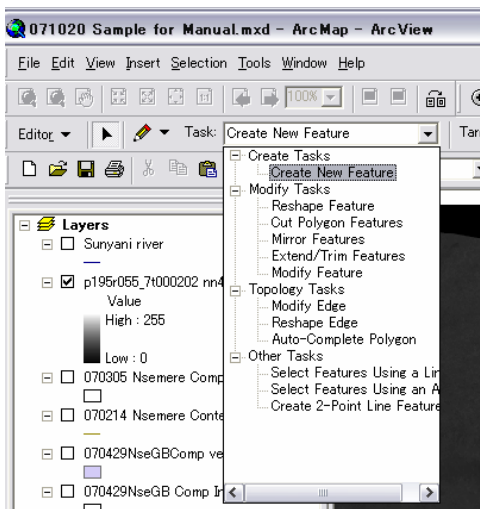
Star edit => Set Task as “Create New feature” => Set target layer “River sunyani” => Strert tracing the river line on the Satellite TM picture => Save the edit result.

a. Start Editing

(a) Crick edit and select start edit within the pull down menu.

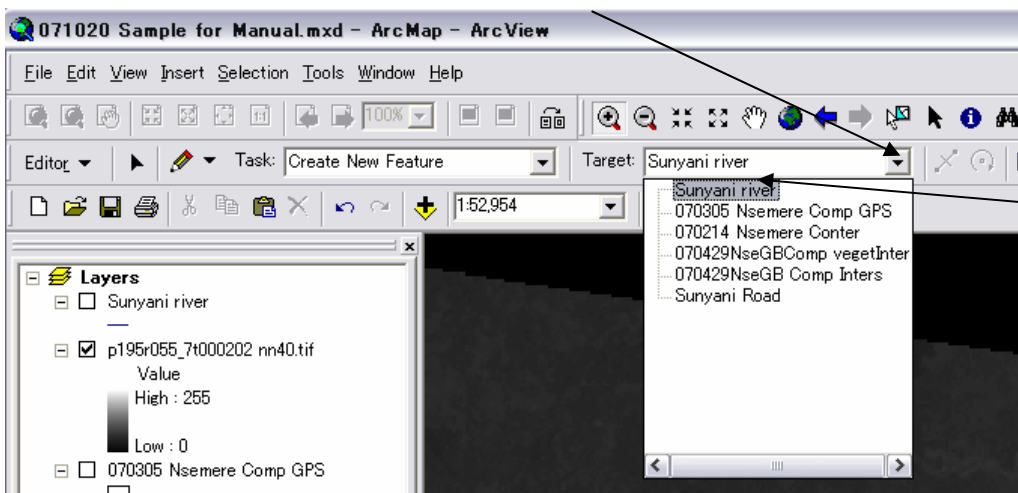


(b) Open pull down menu on TASK and select “Create new “Feature”

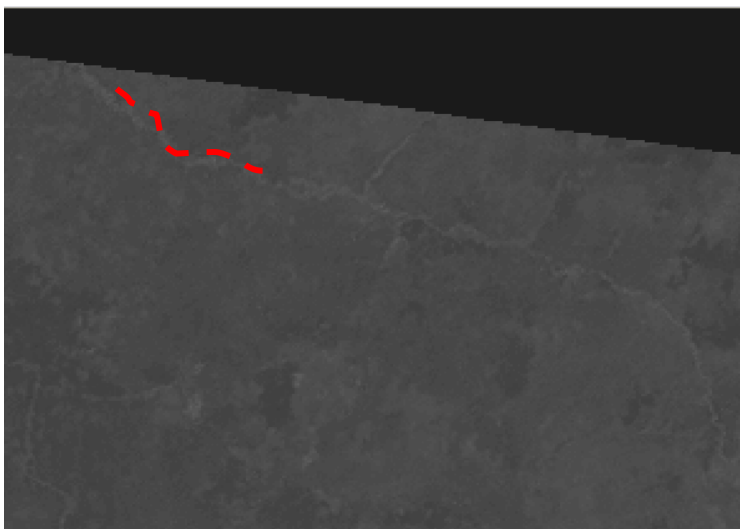


b. Set a target layer for editing

Open pull down menu on TARGET and select a layer “Sunyani river”



(c) Trace river lines on the Land Sat TM image like bellow.

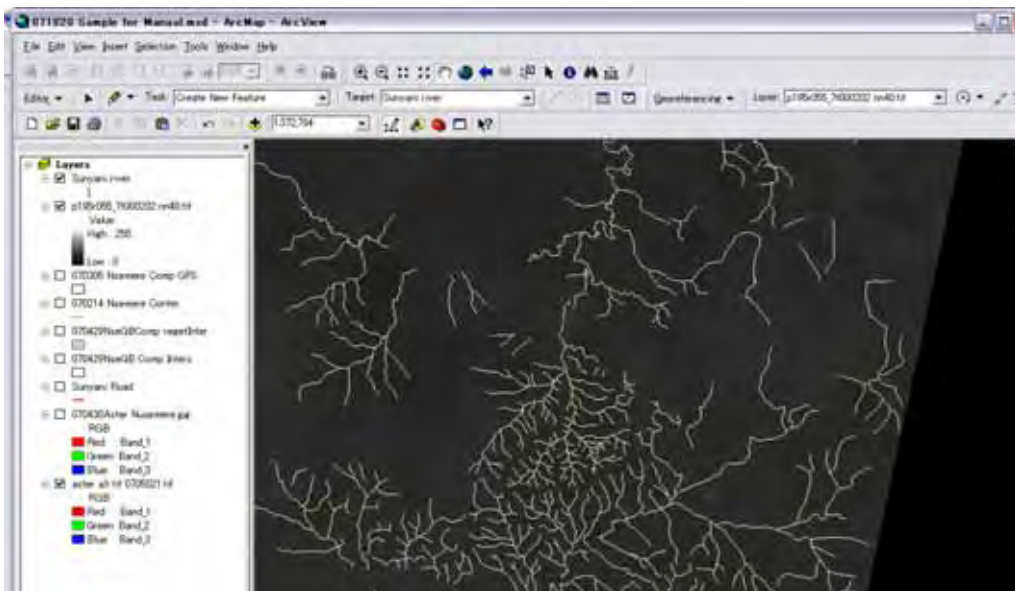
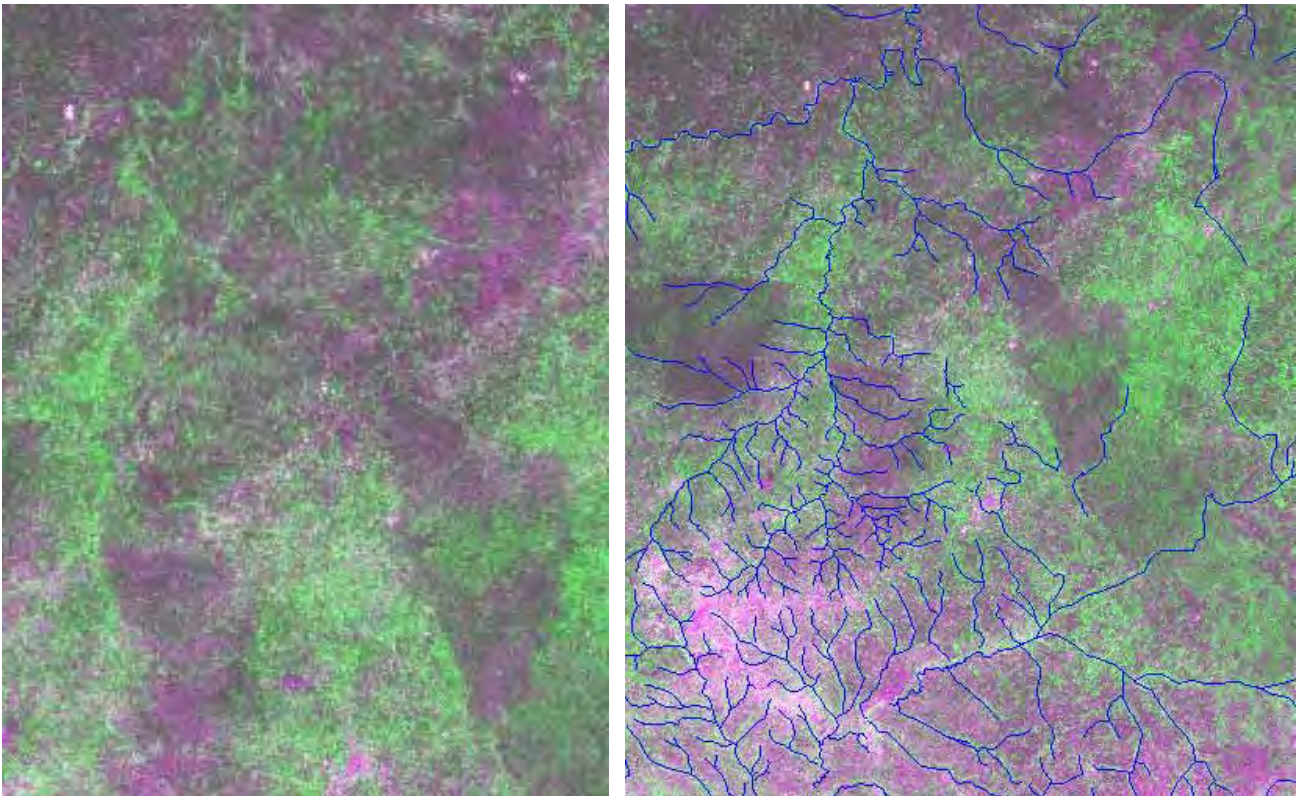


To zoom in you can see river lines and national roads. Last figure shows the area surrounded Tain1, Yaya and Nsemere. Then create new shape file (layer For making digital map using road, river and typical Landmark such as air strip.

Left side black and white picture is Satellite (Landsat TM), you can identify the river lines.

Follows is traced rivers image.

Digital map defined the location the same as coordination system Satellite TM You can measure distance on the GIS Map.



(4) Save the drawing for river line.

When you finish the drawing the river, you have to save the edited data and save map data before exit.

Edit button => save the edit => end the edit => click File => save on the same map file => Exit

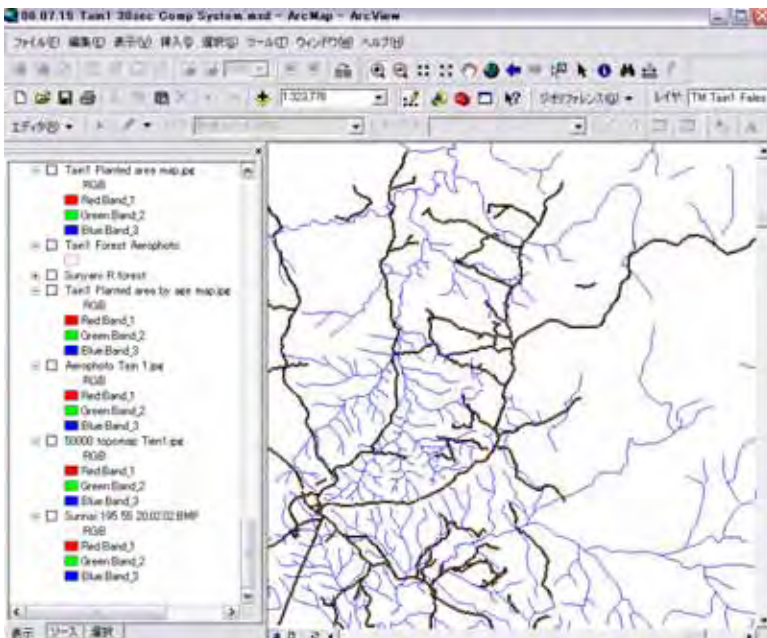
Small advice: During your editing work, you save the edit occasionally. Computer occasionally freeze as your miss operate or un-understandable reasons, then if you did not save the edit, you will loss the edits. You have to repeat the same edit again and again.

After above process had completed, you can start continuous work after lunch.

(5) Practice for making road (national road) shape file and show on the arc map.

The procedures are same.

- (a) Make new shape file using arc-catalog.
- (b) Drag and Drop the shape file to arc map.
- (c) Edit (make new feature/ trace road line and junctions as you can identified).



After traced River and road the digital Base Map above is formulated on Arc Map.

Small advices

(1) File names is important to identify the meaningful file detect later. During GIS analysis especially creating complicated polygons for vegetation, land-use planted areas, harvested areas, compartment, etc. etc. and many times of Geo-processing many shape files accumulate in your PC/ Folder, You may make many errors, and error files also accumulate in your computer, soon you can not manage what file is latest amended one. The file name order is helpful to avoid future confusions.

(2) Error files shall be delete from arc-map as well as arc-catalog when you recognize the file is not necessary for your further analysis.

Sub section B Set up Administration area of a Forest Reserve /Nsemere on Arc Map

For the Use GIS to Forest Reserve Management Planning, match data have to be introduced to the Arc Map such as area boundary of the Forest reserve, Compartment system, Management zone, vegetation, Teak Planted records, and so on. This section will introduce the procedures to make each layer of above.

1. Introduce Forest Reserve area (Administration boundary)

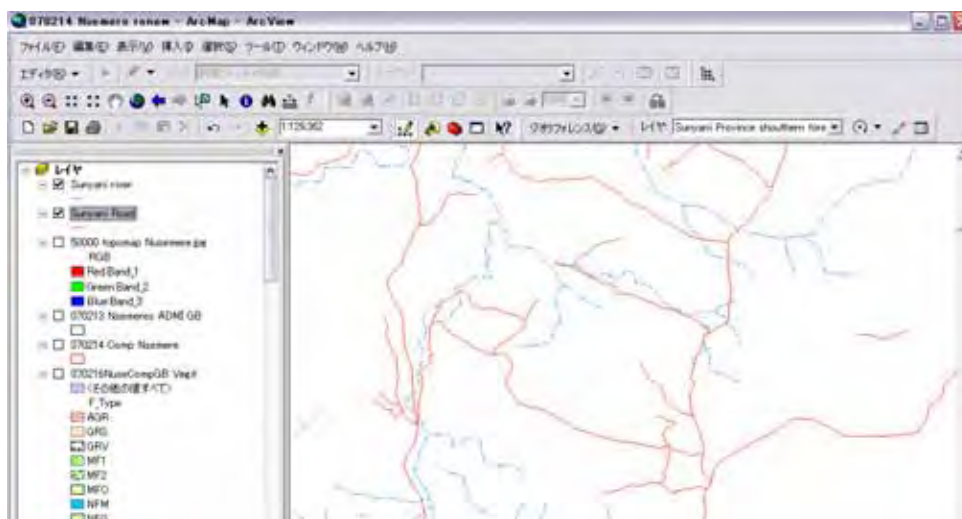
The forest reserve's boundary is generally described on the topographic map. The topographic map described on a sheet of paper. The paper material is scanned, and changed into a digital picture. The picture data call as Luster data. GIS shape data call as Vector data that have the position(arc data on the Arc Map). This part explains how to convert Luster data to Vector data. Vector data has position, length, area data as called "polygon".

(1) Needed material

- a. Base map (Sunyani river and road , 2 layers that was made on sub section A

Sunyani river.xxx, (Line polygon)

Sunyani Road.xxx (Line polygon)



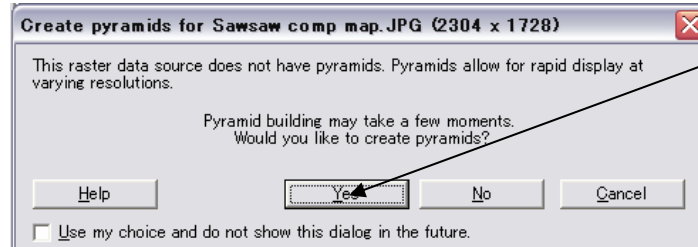
- b. Digitized topographic map 1/50,000 (Scanned and jpeg format Luster data) describing the area boundary lines on the paper map.

50000 topomap Nsemere.xxx (Luster Map)



(2) Process

- a. Store the needed files on your folder.
- b. Run Arc Catalog, and check file list.
- c. Open Arc map that you are saved for making Base map. Drug and drop.
- d. Drug and drop “50000 topomap Nsemere” from Arc Catalog to Arc Map.
- e. If computer ask “Pyramid structure is needed. Do you want?” then answer “Yes”.

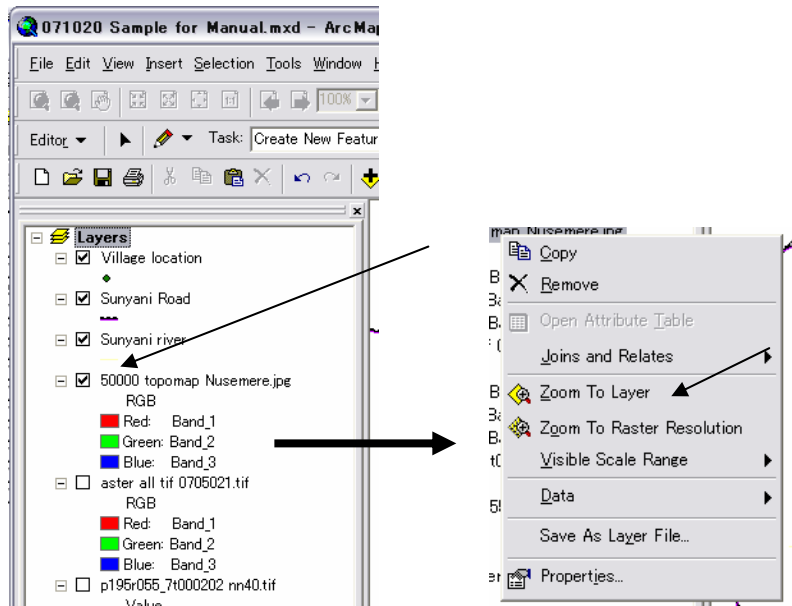


” then answer “Yes”

- f. On Arc Map left side layer name list you find the name “50000 topomap Nsemere”.

Give mark to “50000 topomap Nsemere”. Put the cursor on “50000 topomap Nsemere”. And click right button of your mouse. Then a menu window come. Crick describe all the layer command.

Right crick then following menu windows will come. Then crick Zoom to Layer.

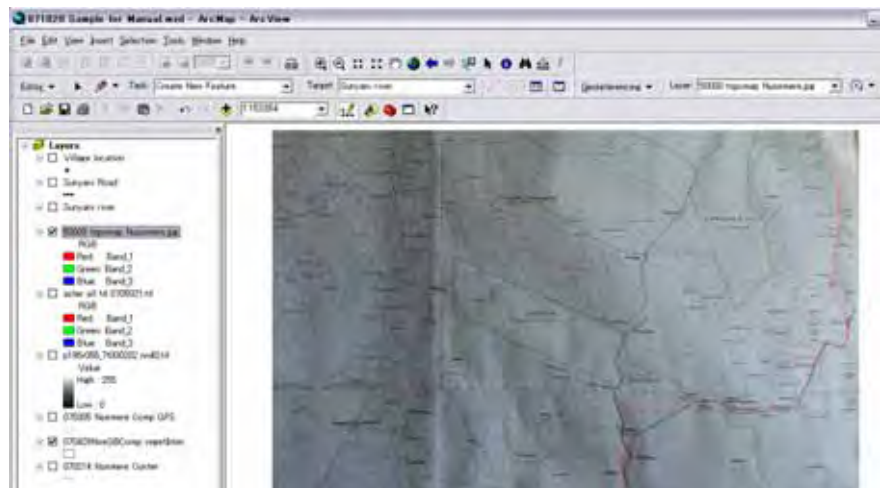


The Arc map shows topographic map that you scanned.

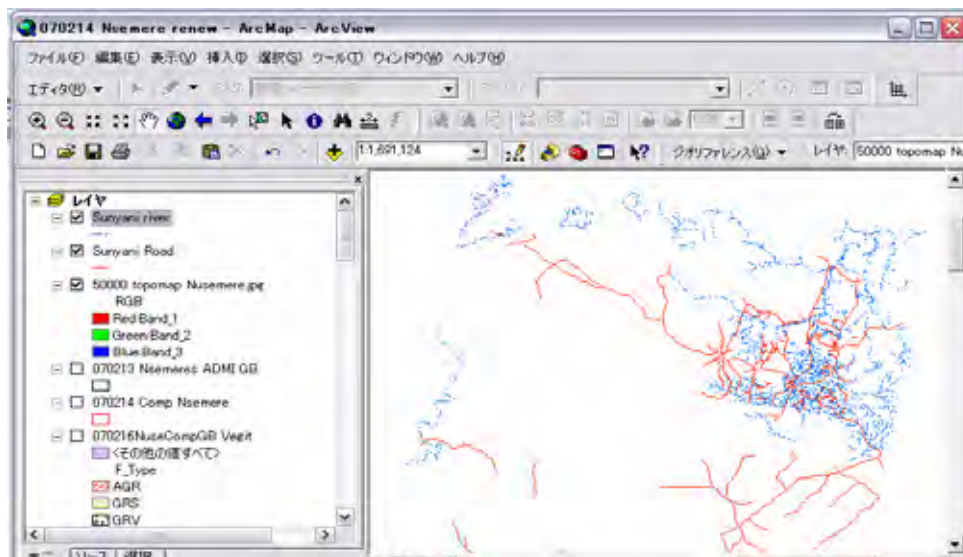
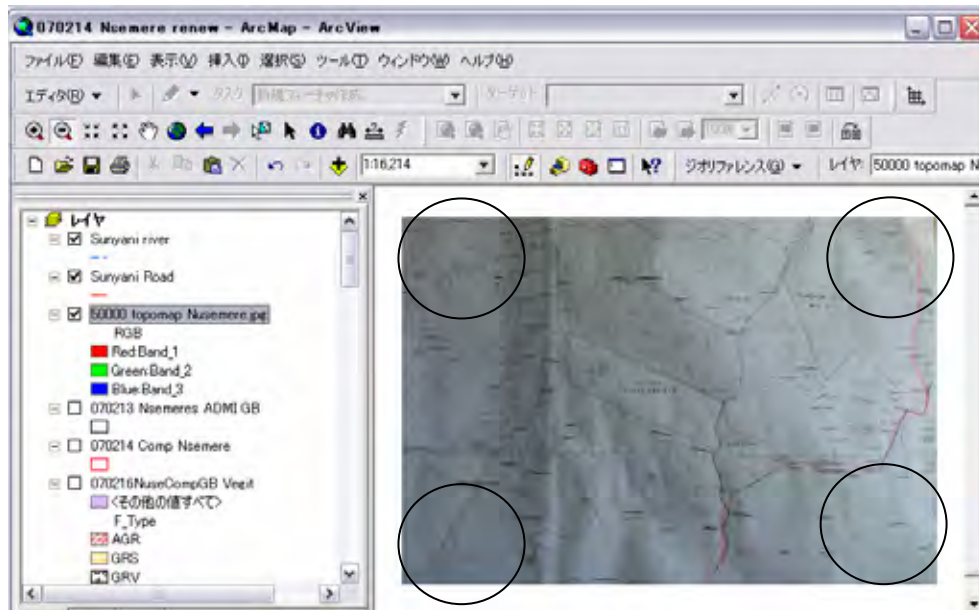
Right figure shows the luster map. But the position of the luster map is not defined yet, therefore; this map’s road and river lines are needed to adjusted the location into vector data base map using “Georeference” function of the Arc Map.

First, you need to harmonize the luster map covered area and the digital base map covered area.

Remember the area covered the




topographic map upper right area, upper left area, lower right and lower left area. Main roads, main river line, and main towns covered the topographic map.

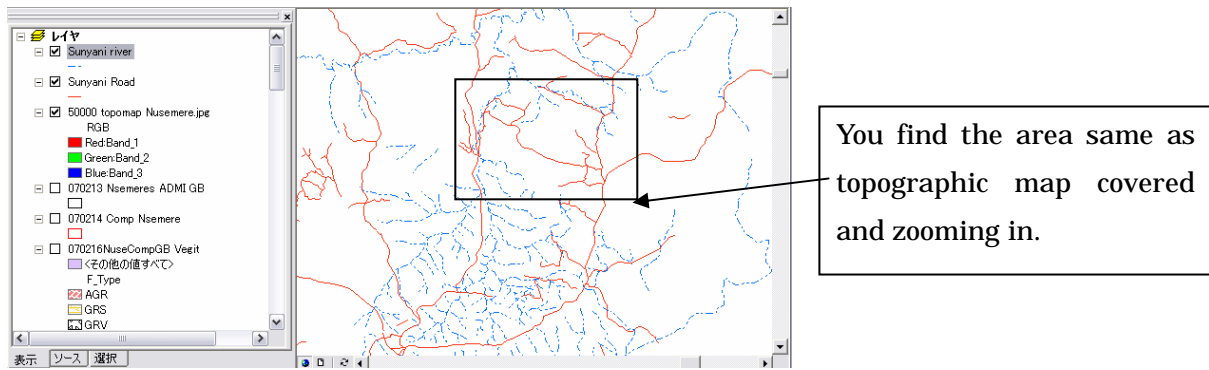


Then right crick “Sunnyani river” and select fit the layer all command same as above. The Arc map screen will change the full area of sunnyani river and road.

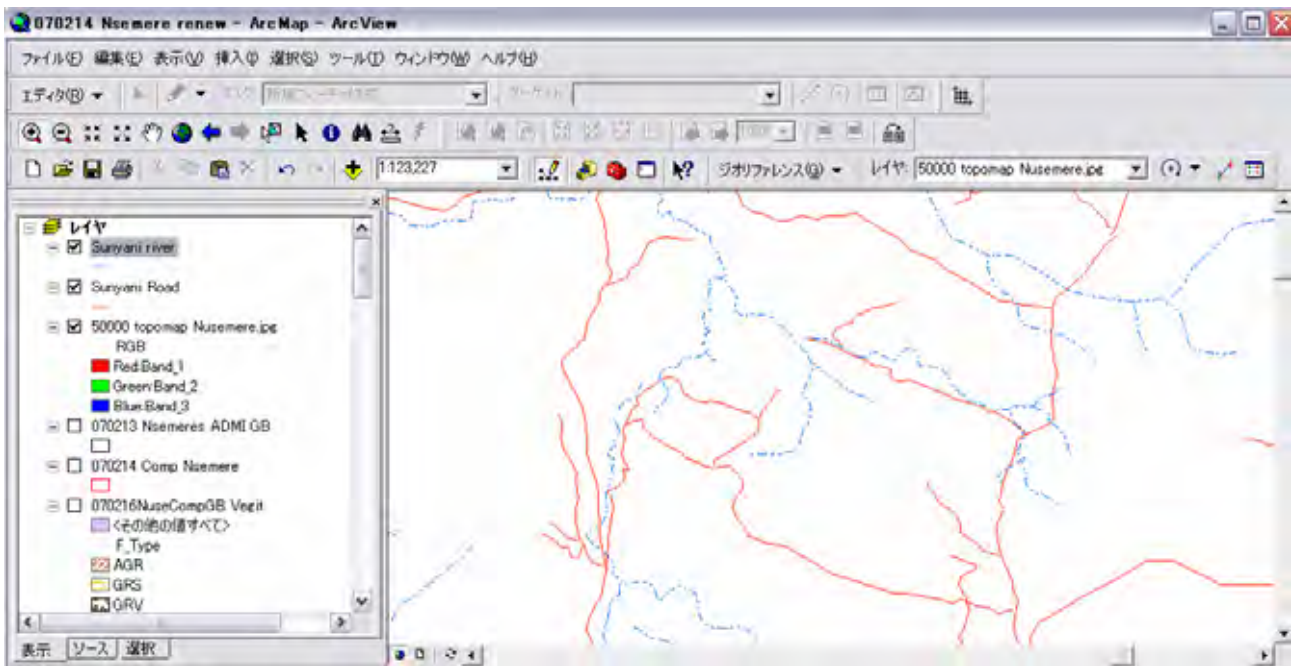
Remember the cover area for adjusting to vector map “sunnyani river” and “sunnyani road”

Using  icon, you can arrange the map size zooming in or out. The below map is example to zooming in to show Sunnyani Town areas, Tain1 and Nsemere. Then the almost same area covered with topographic map shall be set on the Arc map window.

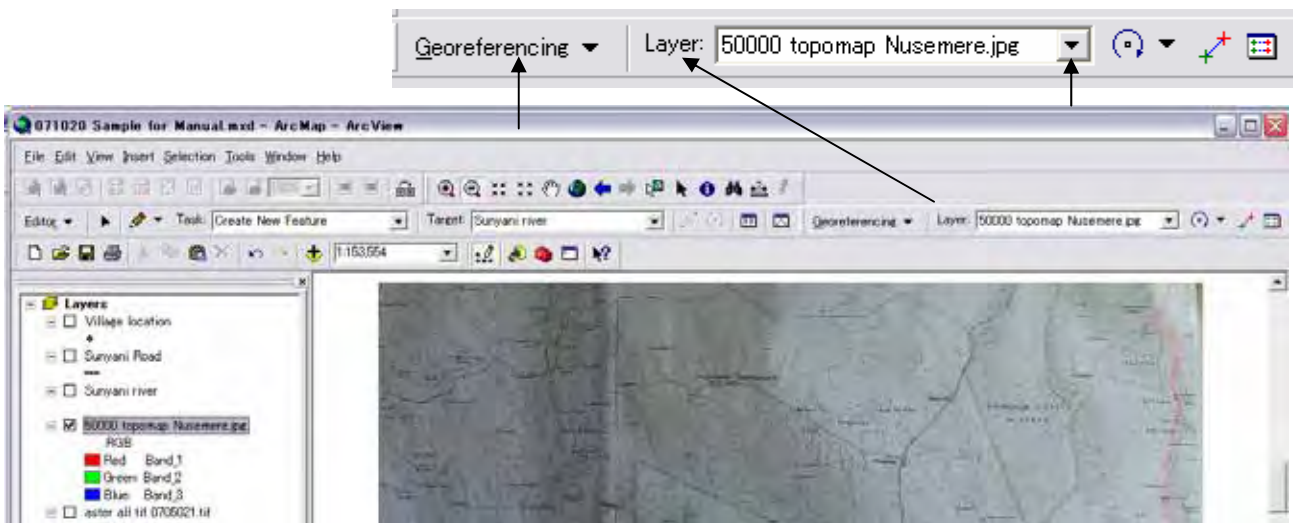
Some zoom in sample shows bellow map.



Following chart is sample for area arranged vector map and luster map.

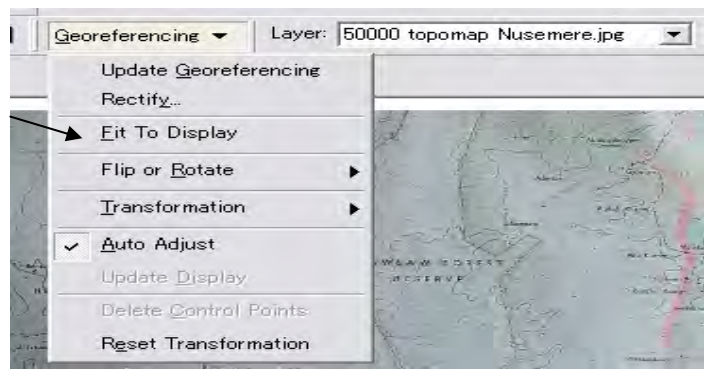



Next, the luster map shows on the same window of Arc Map River and road polygon layer following procedures.



Crick pull down tag of Geo-reference, and select your target layer name for adjusting to vector map (Suryani river

and road). After set the geo-reference column changed to 50000 “topomap nsemere”, click and select “Fit to display” command within the pull down menu. Then the Luster map come to the Arc map. You can start the detail adjustment.



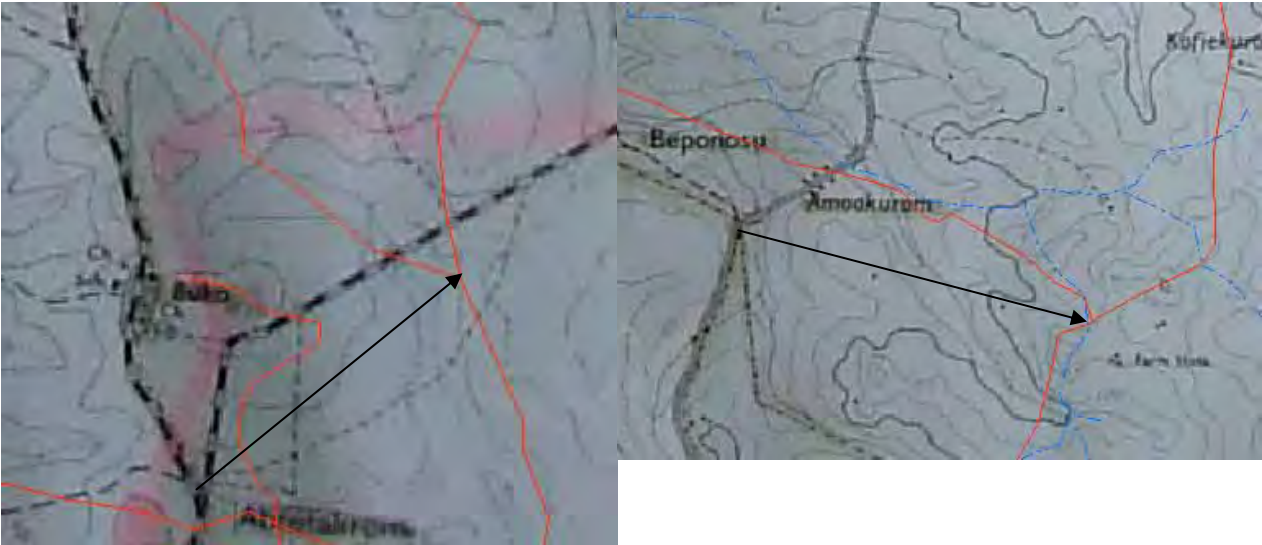
The detail adjustment you use  icons. Left icon manage shifting the luster by hand icon and secular by secular icon. Middle icon manage setting the connecting points from luster map to vector map. The relation of these connection points records are stored connection points table. Use the right icon you can see the table. The table can be saved as text file, and you can recall the table for next time adjusting the luster map to vector map.


Fitting measures are follows.

- a. First screen on Arc Map
- b. Find the clear points on Luster Map and Vector Map such as junctions, river corners.



Expand each points for more accurate adjusting.




These adjustment points shall be selected four corners parts of the Luster Map. The balance of the adjusting points is effect for accuracy of the adjustment. For adjusting points, you use  icon.

After adjusted, the Arc map shows Luster map on the vector map.



After adjusted +->+ mark shows adjusted points.

The adjusted record is stored on the table. The table you can call by crick the  icon.

If your adjusting was made error, you call the table and erase the last adjusting points from the table; you can tray again to other adjusting points.

The table is below.

Link	X Source	Y Source	X Map	Y Map	Residual
1	1174.064725	-680.562269	591525.581723	832071.272429	267.63742
2	339.314926	-530.058354	579377.023710	833864.245017	79.37412
3	1240.765950	-410.746222	592229.792070	835323.479904	352.15695
4	1534.659857	-939.973418	596637.730429	828454.029820	210.02640
5	1165.028824	-988.568015	591268.148652	827484.521999	53.26545
6	1126.167480	-1309.357030	590810.029572	822743.522216	188.99633

Auto Adjust Transformation: 1st Order Polynomial (Affine) Total RMS Error: 217.79672
 Load... Save... OK

Click save button, and give the file name and folder name where the file shall be saved.

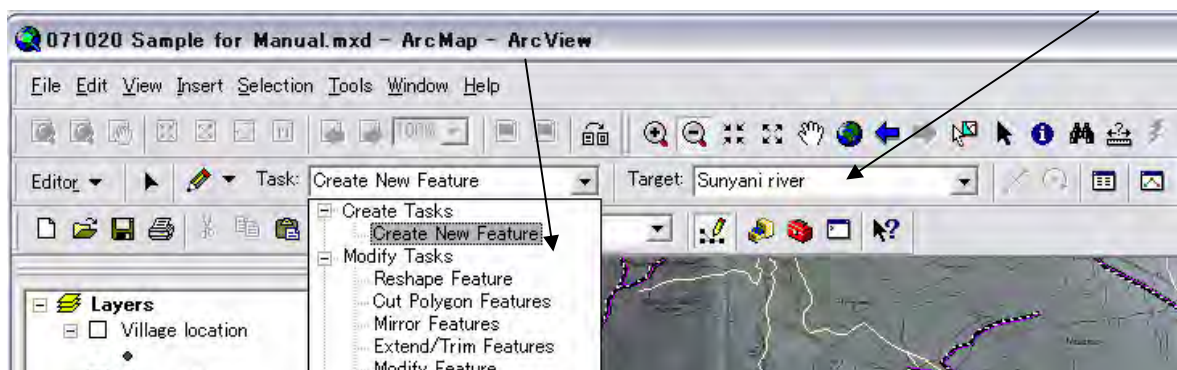
Next times you want make the topographic map on the Base map, you click load button and select your folder, file name, the computer automatically make adjusted picture on the Arc Map again.

(3) Delineate polygon for administration boundary on Arc Map.

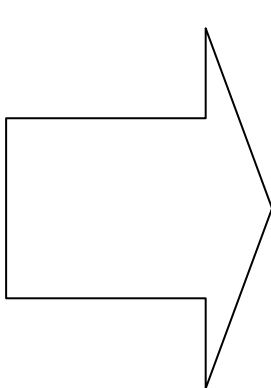
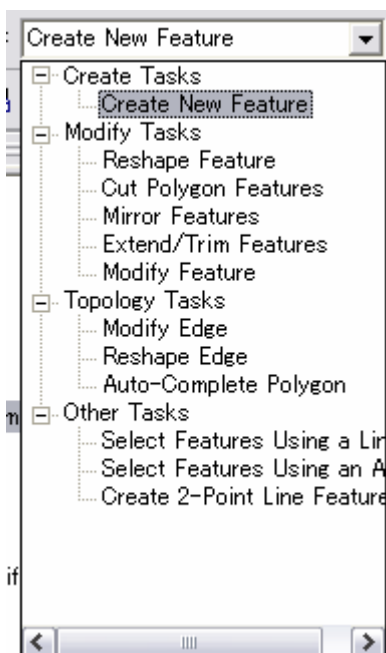
Trace the luster map Nsemere boundary line for polygon (convert to the Vector map “admi nsemere”).

- a. Prepare new layer file named “admi nsemere” on Arc catalog (process is same as explained for making new layer for making base map as “river sunyani” and “road sunyani” (Subsection A, 3, page 16). Import a coordination system from “river sunyani”.
- b. Drag and drop the “admi nsemere” to Arc Map.
- c. Start editing.
- d. Create new features.

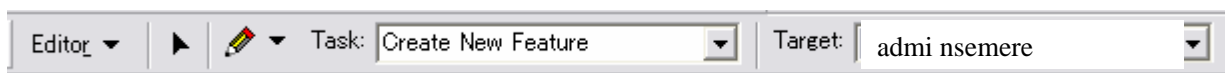
Select “create new features command within the pull down menu. Set the target “admi nsemere” on the target column. Then trace the boundary using pencil icon below. For creating or amending features, check the name of the targets layer.



Commands in the pull down menu for feature making, amending etc.

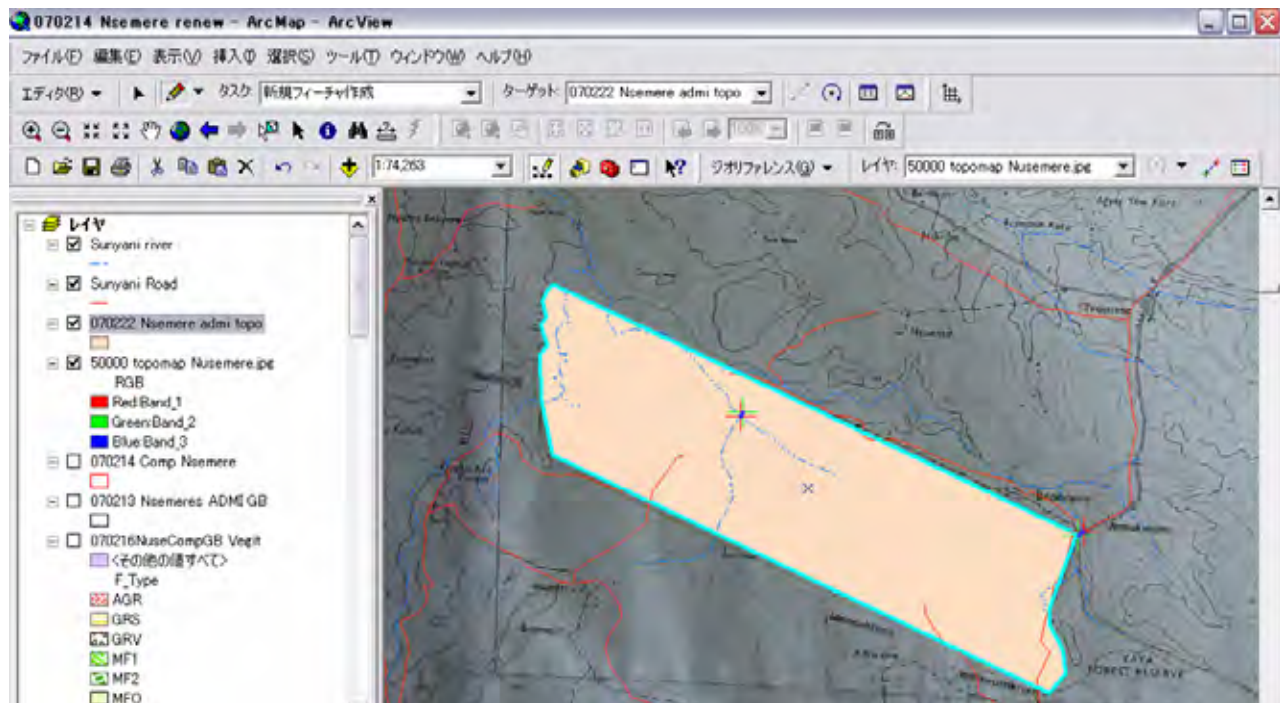


- New feature making
- Change the feature
- Change the feature shape
- Cut a polygon
- Create parallel line feature
- Cut a line feature/ polygon
- Amendment a polygon



Set the target layer name. Then start delineating, tracings boundary line on Luster map.

Then following new shape had made.



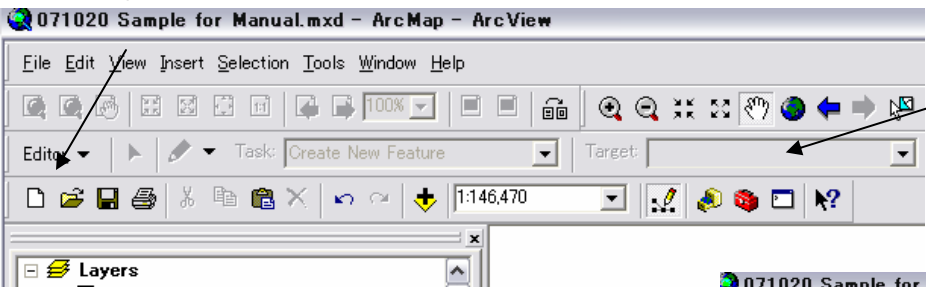
(4) Area calculation

Nsemere forest reserve is 1813 ha officially.

The area calculation is carry on the data table of a field. You have to make a new field for area on the data table of the layer “admi nsemere”. The data table amendment (add fields, calculation area, etc.) is needed to carry under the Stop Editing condition. For area calculation a area calculation formula shall be road to the calculation window. Process is following:

a. Add a field on the data table of the layer

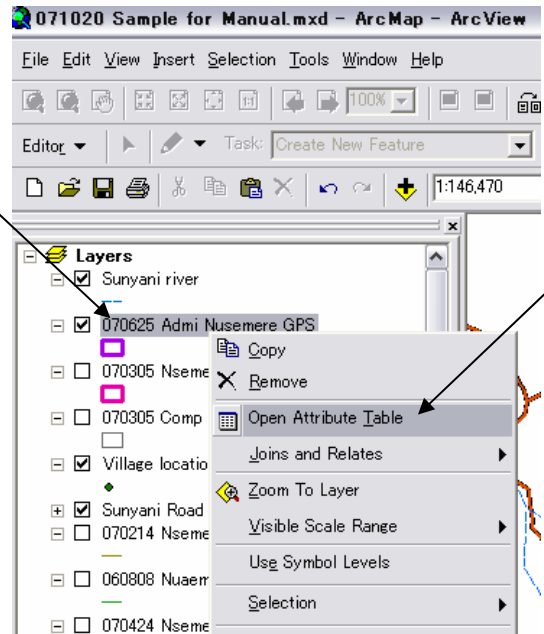
End editing =>



Set “admi nsemere”

b. call the data table.

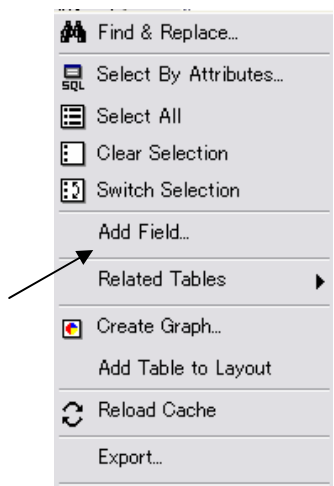
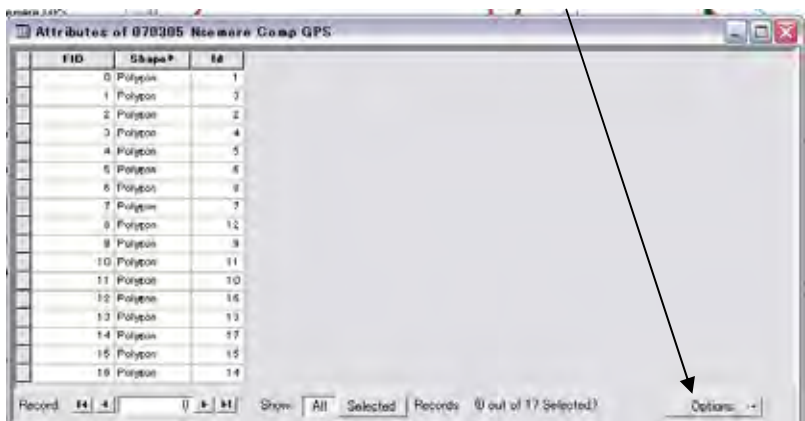
Call table (right click the layer name -> Open attribute Table.

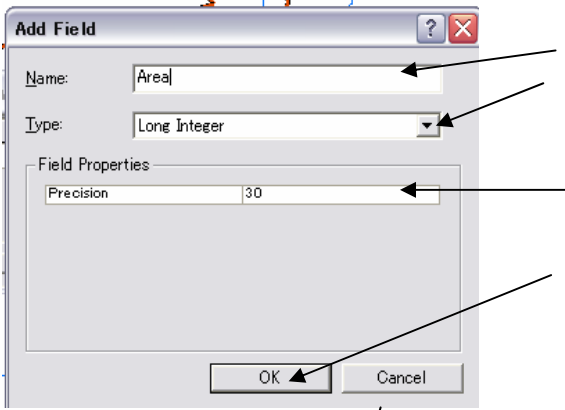


c. create a field for area on the attribute table.

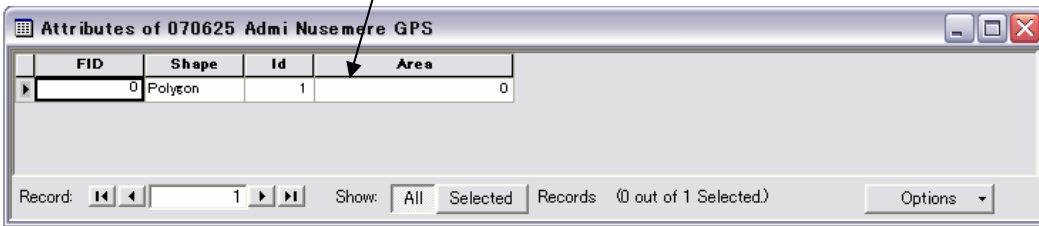
Crick option button on the attribute table => crick add field in the pull down menu then add field window came.

Type in The field name “area” => select the field data type (Long integer) => type in precision (30) =>OK





Then table automatically change to show the new field for "Area".



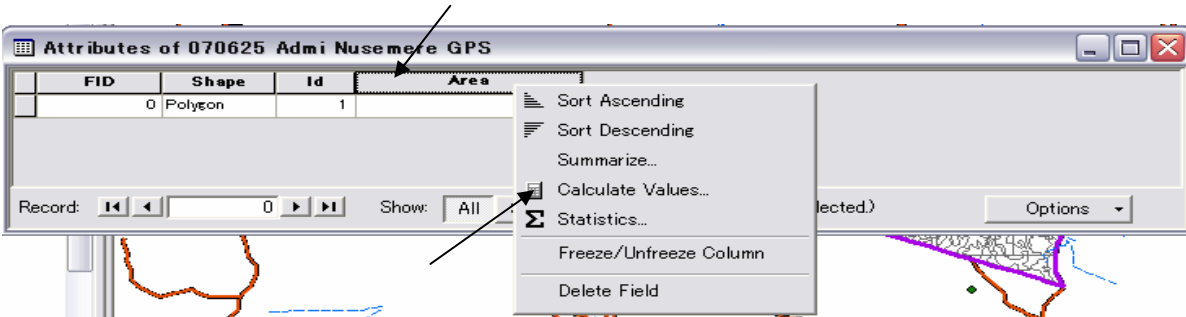
d. Area calculation

Data calculation shall carry under the edit condition.

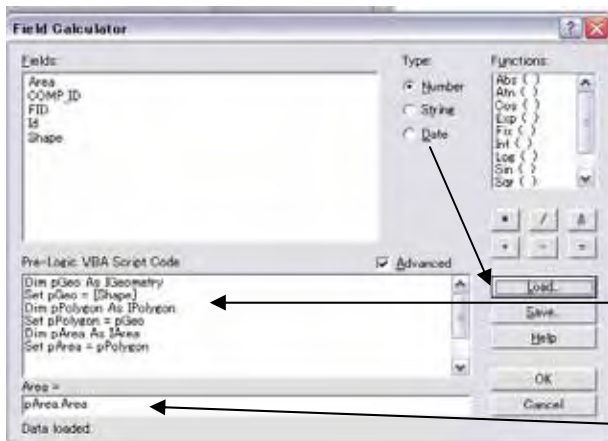
Edit => Start Edit => set target "admi nusemere" (Task "create new polygon")

Crick Field name by right button => click calculation icon then.

=> type in field name, type of data, size of column Crick new field => crick calculator icon



Field calculation window shows bellow will come.



06.06.22 Area calculation Expression.cal

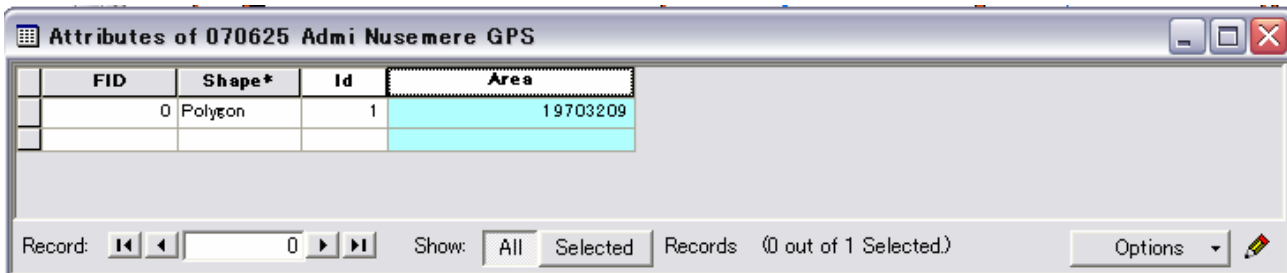
```
Dim pGeo As IGeometry
Set pGeo = [Shape]
Dim pPolygon As IPolygon
Set pPolygon = pGeo
Dim pArea As IArea
```

```
pArea.Area
```






Load area calculation formula from your folder.

Area Calculation formula is stored in a  06.06.22 Area calculation Expression file.

Then OK. The area is calculated on the data table.



FID	Shape*	Id	Area
0	Polygon	1	19703209

Record:   0   Show: All Selected Records (0 out of 1 Selected.) 

The computer calculated 1970 ha.

The area shows 1970 ha. It means that the boundary line described on the topographic map is not collect. Amend the polygon to meet the area same as 1813 ha. This amendment is depends upon the knowledge and information about the position of boundary post.

2. Another way to fix boundary line with GPS Data.

In general, the boundary lines described on the 1/50,000 topographic map of the forest reserves are not so accurate. Therefore, you have to conduct land survey for boundary post location.

Carry a GPS and to go to each boundary post for reading GPS points (Longitude and Latitude). You mark the place to GPS, then make a table like shows on right.

Post number	D	M	S		D	M	S	
2	N	7	30	39.3	W	2	10	45.9
5	N	7	31	5.9	W	2	12	00.9
6	N	7	31	15	W	2	12	25.8
7	N	7	31	23.8	W	2	12	51.0
8	N	7	31	32.9	W	2	13	16.1
9	N	7	31	46.3	W	2	13	54.0
10	N	7	31	50.7	W	2	14	05.6
11	N	7	32	0	W	2	14	31.8
12	N	7	32	26.2	W	2	14	36.7
13	N	7	32	50.1	W	2	14	41.0
14	N	7	33	15.8	W	2	14	41.9
15	N	7	33	36.6	W	2	14	40.8
18	N	7	33	4.6	W	2	13	27.9
19	N	7	32	53.8	W	2	13	03.6
21	N	7	32	32	W	2	12	15.0
22	N	7	32	21.4	W	2	11	51.0
23	N	7	32	10.6	W	2	11	26.8
24	N	7	31	59.6	W	2	11	02.1
25	N	7	31	43.7	W	2	10	25.3
26	N	7	31	38.1	W	2	10	14.5

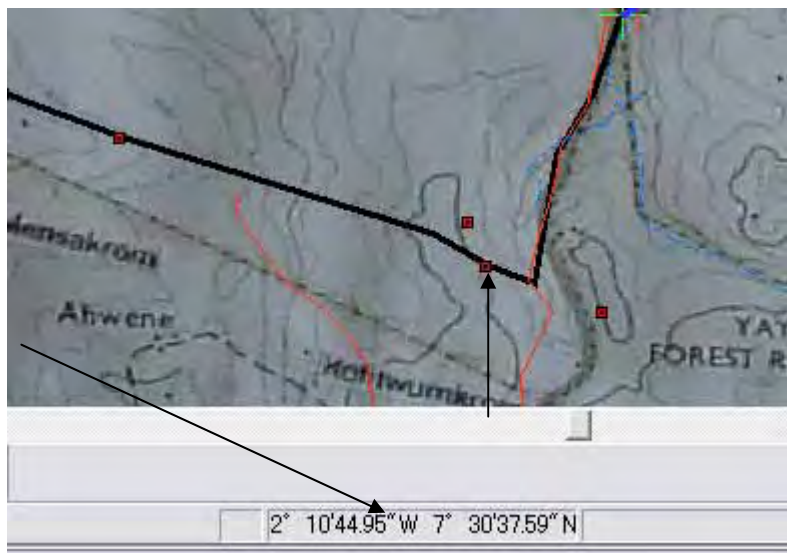
Next, you make point polygons of these boundary post position on your Arc Map. Measures are following.

Make a new layer for boundary post (Point Polygon) on Arc Catalog => drag and drop the file to Arc Map => Change Map Unit from Meter to Degree, Minutes, Second Units (Map property) => Start editing (target i

Layer is "Nsemere Bound Post") => hold pencil icon and move the cursor to the point observing right down part indicator (showing the cursor position by Degree, minutes, second units). If you want fix the cursor just on the points, zoom in, it may more easy to find the collect position on the Arc Map.

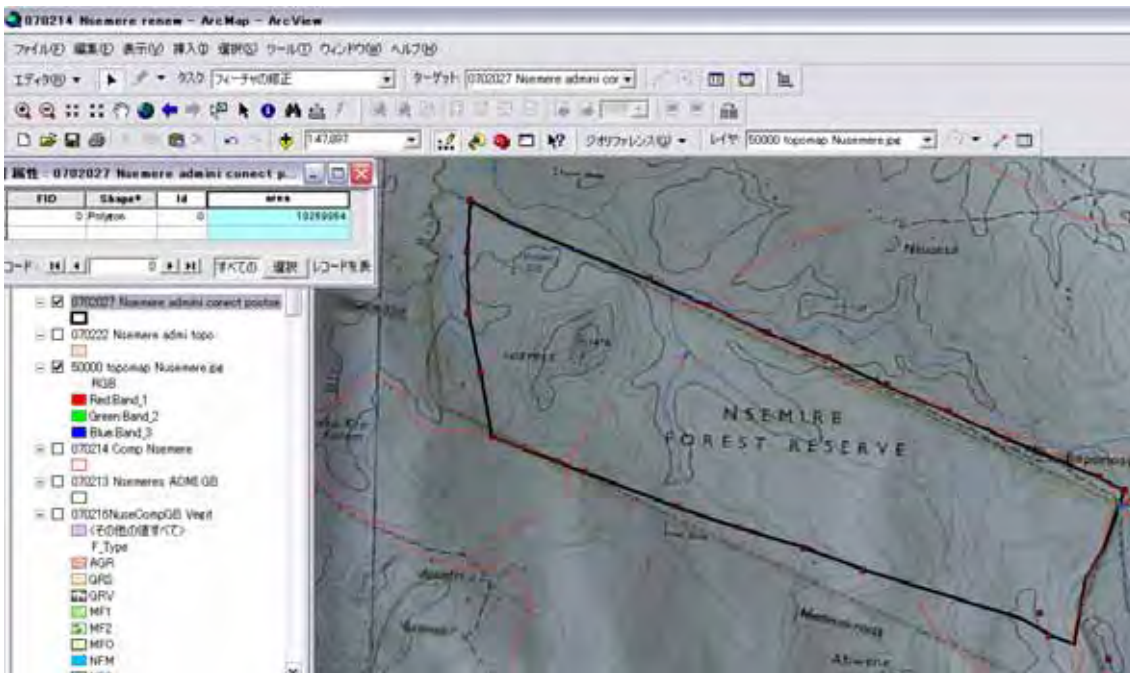
Next picture shows the example that GPS reading result was trans-planted to the Arc Map.

Right bottom side, Longitude and latitude indicator of the cursor (Just put on a boundary post arrowed No 2)



Make a polygon connecting with boundary posts "admi nsemere".

Below is administration area shown by the GPS land survey.

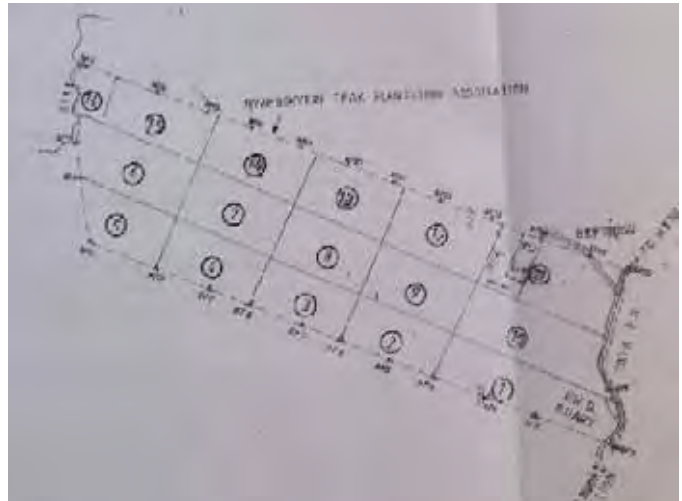


The area had been defined by GPS survey. Total area shows 1927 ha. If the boundary post mined exact place and not moved, the area is 1927 ha but 1813 ha.

Sub Section C Set up Compartment system

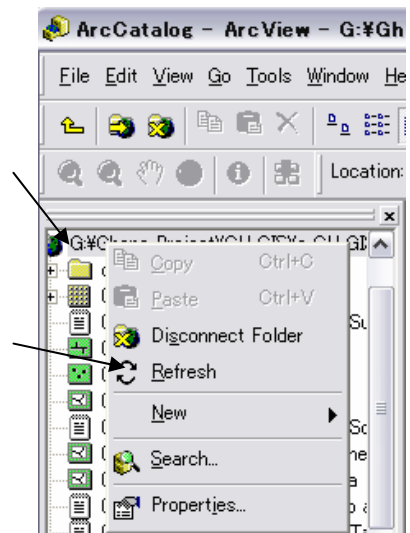
(1) Make exited compartment using luster map of FSD.

Paper map on existing compartment shows right. The map is needed to convert to vector data (shape file).



- a. Scan the FSD compartment map to Luster data and store on your folder.
- b. Open Arc Catalog and add the Luster data file on the list using “refresh” function.

Right crick on the folder calling pull down menu => crick refresh
Then Arc catalog read new files that you add on your folder.



c. Open Arc map, and renew the Arc map file list and make a new layer for “Comp FSD Nsemere”

d. Drug and Drop “Comp FSD Nsemere” to Arc Map.

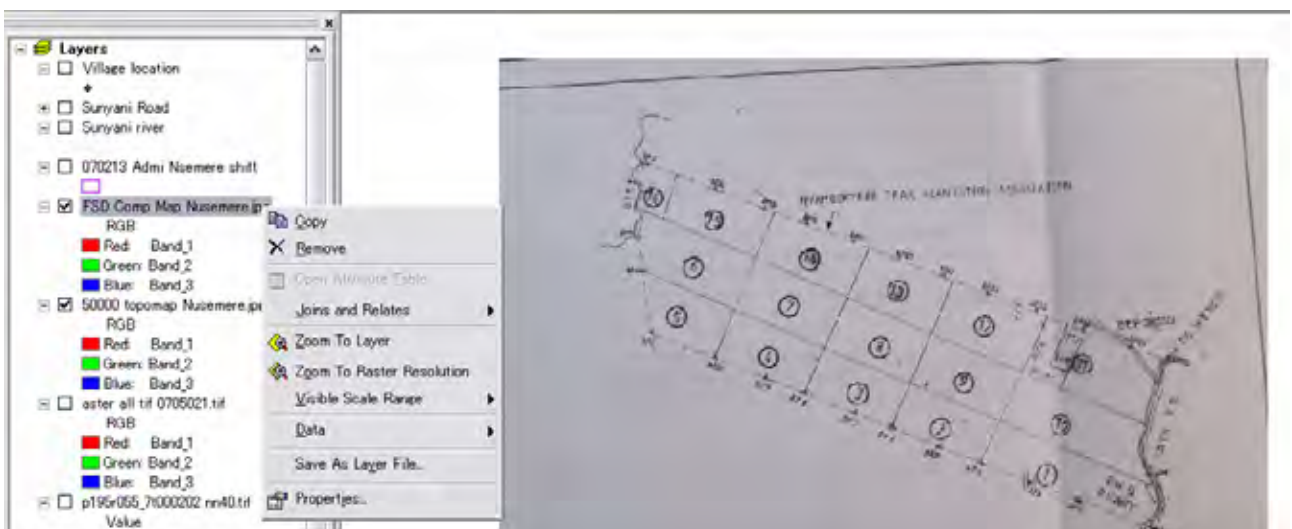
e. Adjust the location of the Luster map to administration area.

Process is same as administration boundary layer making (subsection A 1).

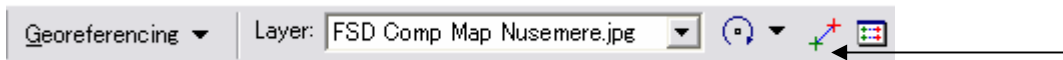
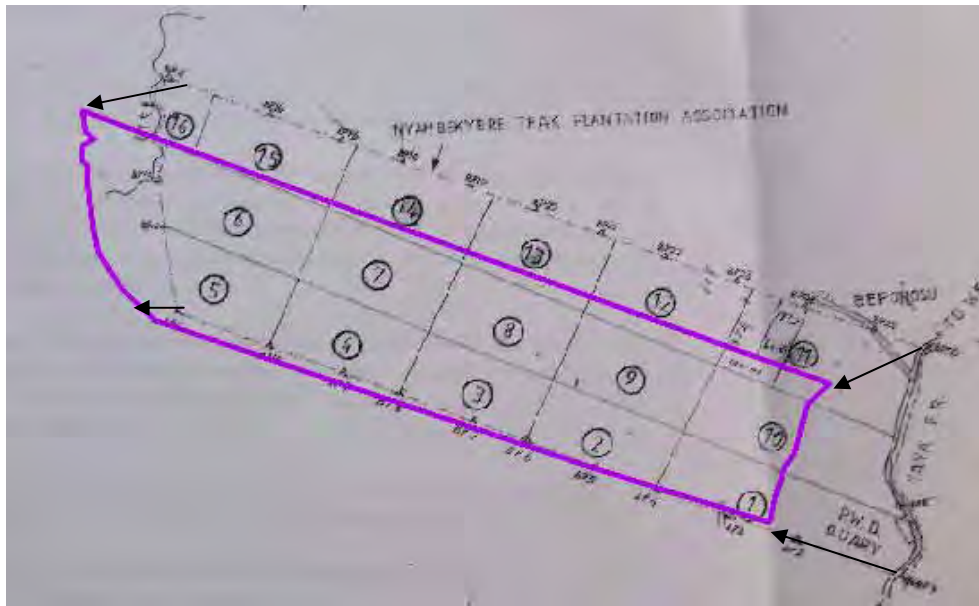
Give Check mark FSD Comp Map Nusumere.jp => Right crick layer

name => Crick Zoom to Layer

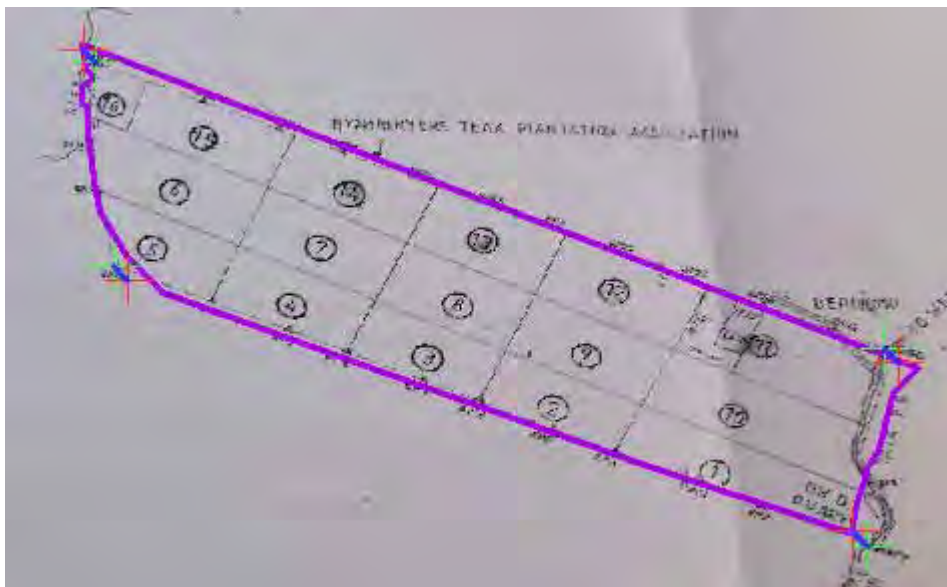
Then following picture come to the Arc Map window.



Adjust the luster compartment map to vector administration polygon using georeferencing function.



Luster map adjusted to Vector administration layer is as below.



d. Make new empty layer for FSD compartment Nusumere (Polygon).

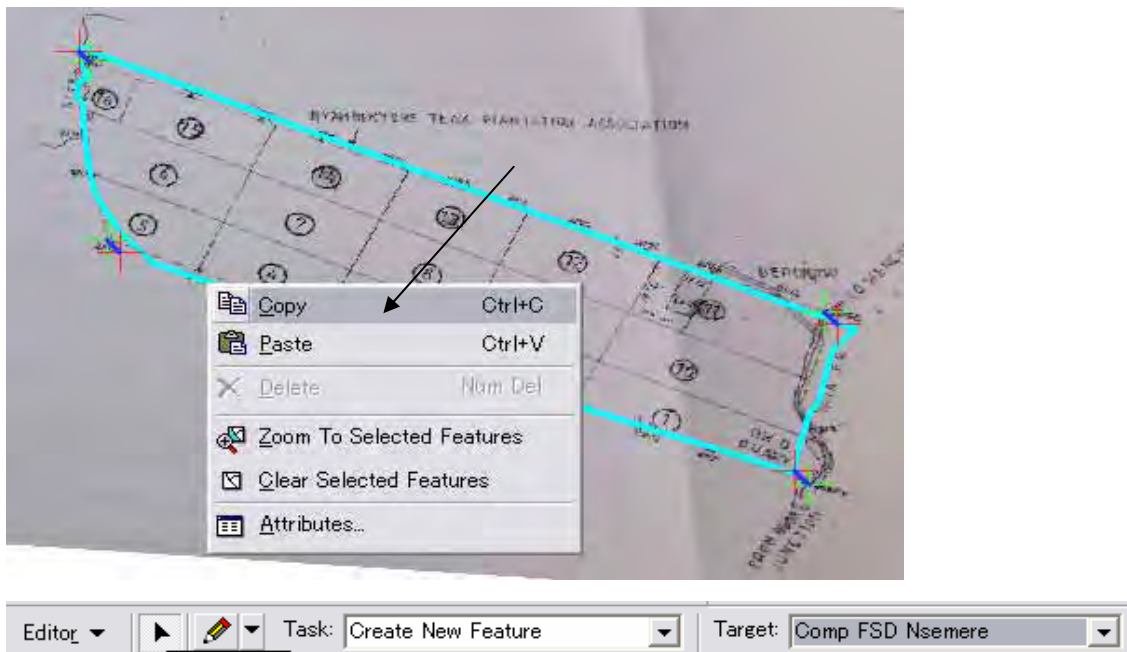
Open Arc Catalog => File => New => shape => define shape type (Polygon) => Edit special reference => Import => select "sunyani river" => OK => apply.

Drag and drop the new shape file to Arc Map => give mark active on the layer list.

Start Edit => Set “Creat new polygon on task column => Set Target column “Comp FSD Nsemere”
 Copy administration polygon to “Comp FSD”.

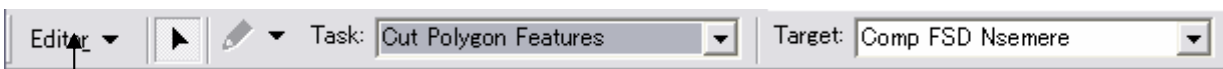
Select a polygon (administration: changed polygon outline into right blue, copy then past on the new layer “Comp FSD”. Set Taks column and Target column on edit bar as above. (“Create New Polygon” on Task, Target on “Comp FSD Nsemere”)

Then outer boundary of the forest reserve is made as the part of Compartment layer. The compartment is made by dividing the administration area based on (tracing) Luster map adjusted the position (georeference) to the administration layer.



e. Divide administration area into compartment.

Edit => Start editing => Check editing target (“Comp FSD Nsemere”) => Set Task “Cut Polygon Feature”



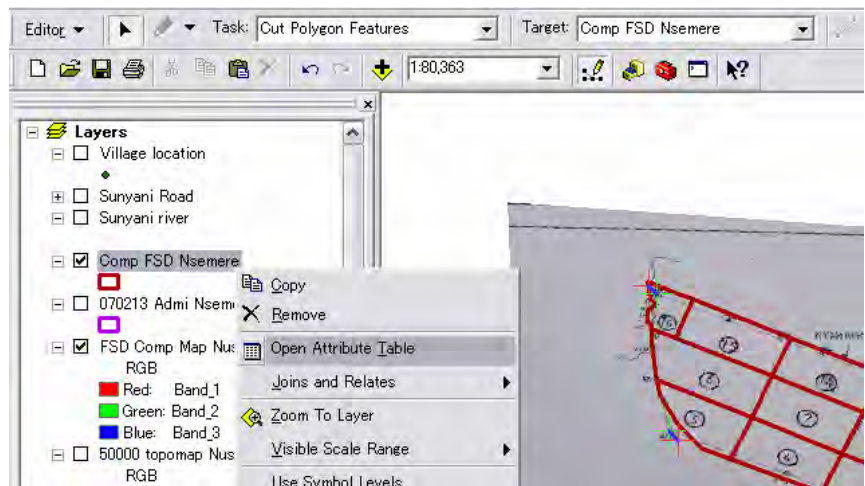
Divide a polygon into compartments using Pencil tool as below sample.



f. Save the divided results on your PC. And arrange data table for compartment ID (No) and area calculation.

Edit=> Save edit=> stop editing => open data table = add fields “area” Comp FSD ID”, then start editing => calculate area for compartment

=> give compartment number to each column of the field “Comp FSD ID” => open layer property => give label making commands. Then Arc Map shows compartment FSD on the area defined by GPS survey.

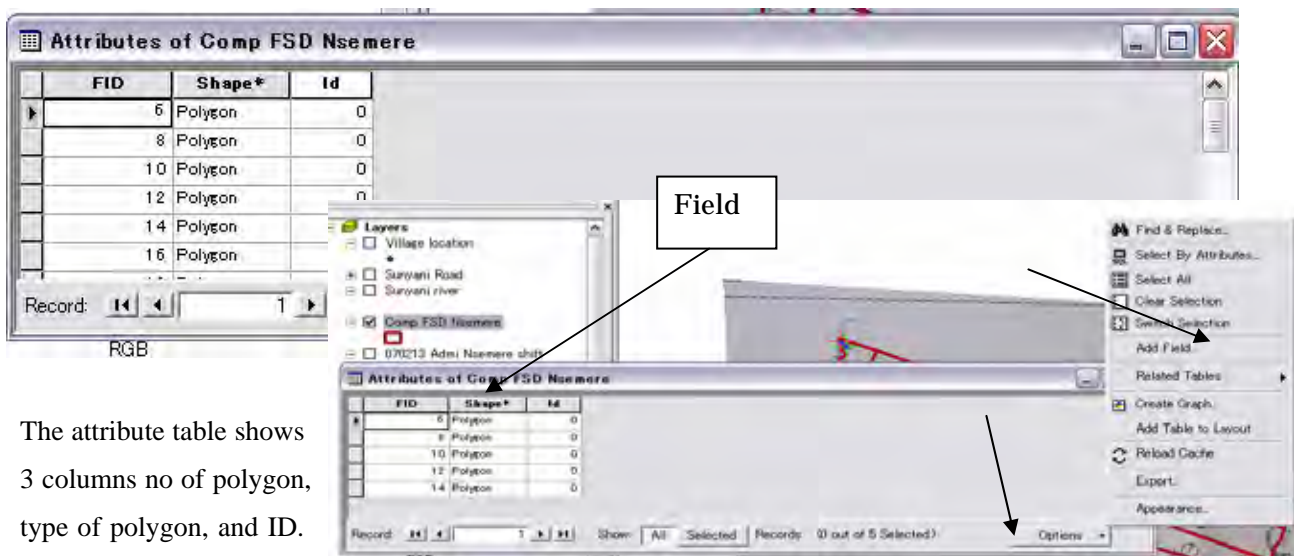


(2) Arrange data table for Compartment Number labeling.

a. Open Data Table(attribute table).

Right Crick layer file name => select “Open Attribute Table.

Following table will come.



The attribute table shows 3 columns no of polygon, type of polygon, and ID.

The divided polygon for compartment shall be given compartment ID (No), and area. For this data inserting, 2 columns are needed. You have to made new two columns on this data table.

b. Add fields.

Crick Options button => select New field

Then field edit window will come..

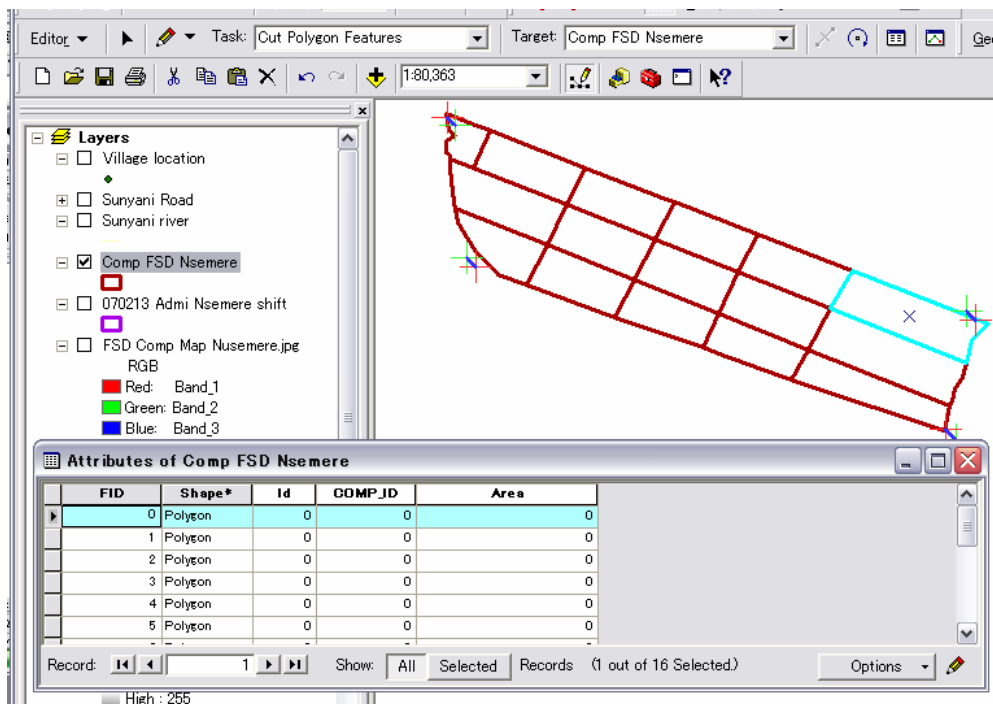
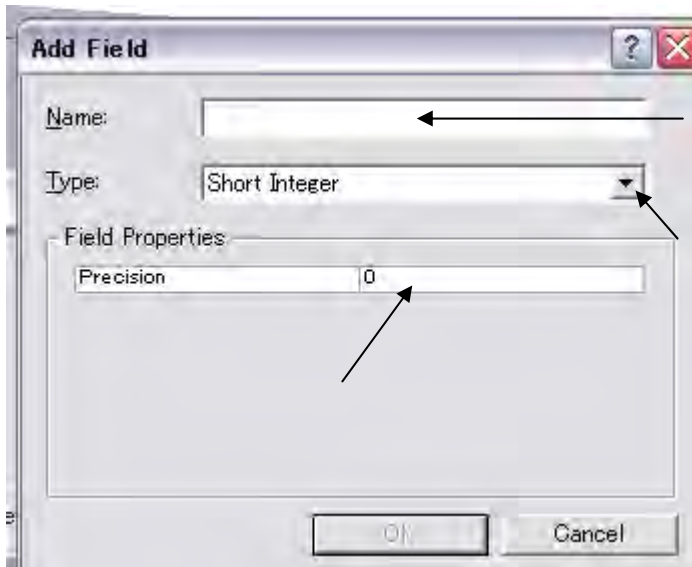
Give field name: Comp No, Area

Decide field type : Short or long Integer or Text

(short integer for compartment No, and Long integer for area)

Decide width of column (Precision) : 10 for Compartment No, 30 for area example)

If Arc Map is working under editing mode, before new column / field making STOP the EDIT.



c. Add Compartment No. to the table.


Edit => Start Edit => select a polygon => crick color changed line of the Compartment field on the data table => Type Compartment number that was read from adjusted Luster compartment map => repeat same to all


compartment.

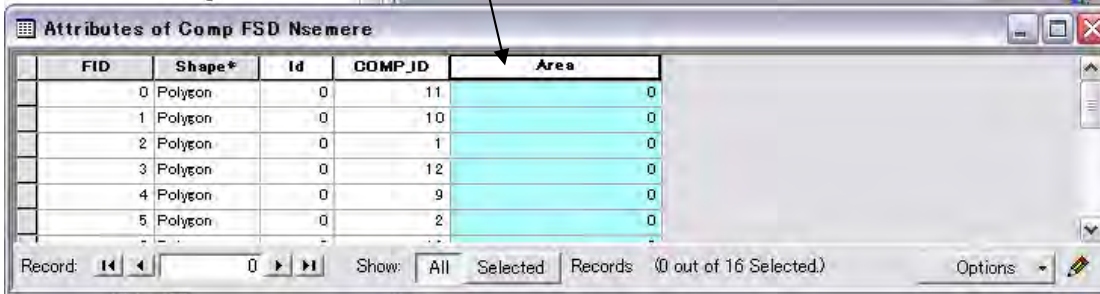
Select a compartment area, then one line of the data table change the color in blue, the line reflects the polygon, so type the compartment number to the field of blue column.

d. Insert Area calculated and Compartment ID to each column.

Polygon data have the information of area. The area calculation is carry on following measures.

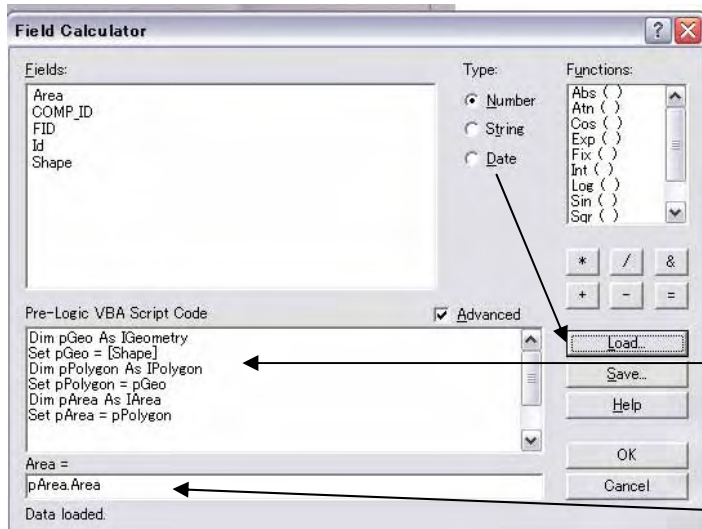
Crick area field title column then vertical columns are change color as selected condition => Right crick  icon within the pull down menu then calculation formulae window will come. => Road area calculation formula file => Crick OK

The area calculation formula is stored as a file named “  06.06.22 Area calculation Expression.cal “.



FID	Shape*	Id	COMP_ID	Area
0	Polygon	0	11	0
1	Polygon	0	10	0
2	Polygon	0	1	0
3	Polygon	0	12	0
4	Polygon	0	9	0
5	Polygon	0	2	0

Calculation formulae window



 06.06.22 Area calculation Expression.cal

```
Dim pGeo As IGeometry
Set pGeo = [Shape]
Dim pPolygon As IPolygon
Set pPolygon = pGeo
Dim pArea As IArea
Set pArea = pPolygon
```

pArea.Area

Then area column filled number of areas in m² base.

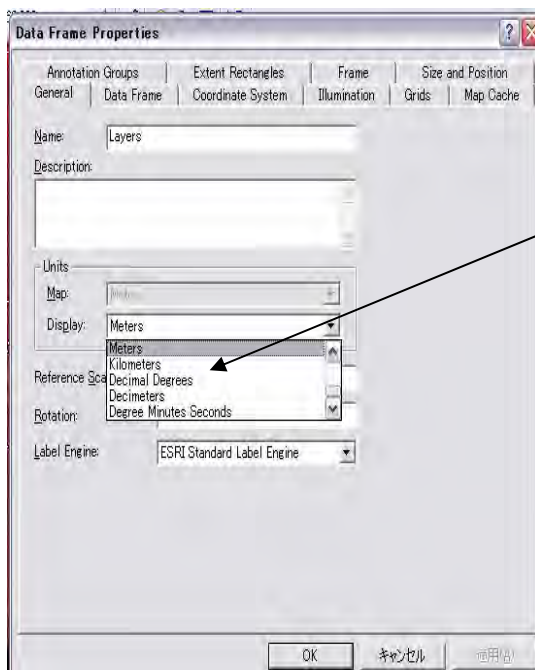
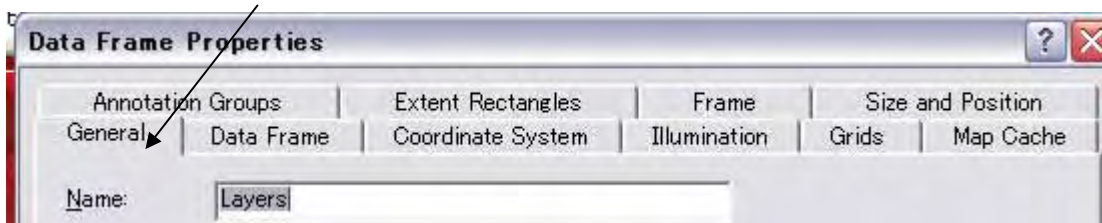
(3) Make new compartment system based on Longitude and latitude line.

Procedures are roughly following 4 steps a. to d.

- a) Make a new layer for 10 second longitude and Latitude line polygon on Arc Catalog named “Parcel Nsemere GPS” (procedure is same as above Sub section A3 (2) (p19)).
- b) Make a new layer for Latitude and Longitude Line (Polygon) unit parcel on Arc Catalog named “LL line Nsemere”.
- c) Divide parcel “Parcel Nsemere GPS” in to parcels based on the 10 second longitude and latitude line.
- d). Combine parcels based on the 30” units into Compartments.

a. Methods for making line polygons of Longitude and Latitude by Grid making function.

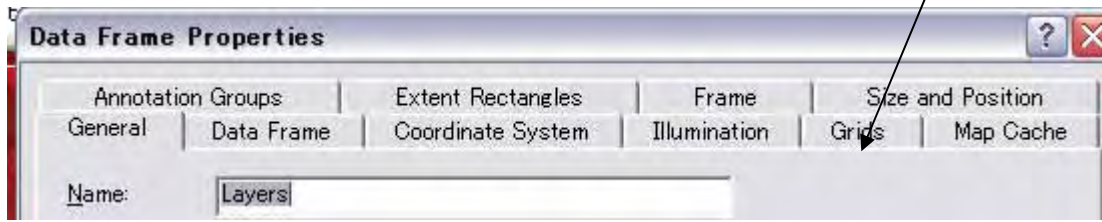
a.1 Change layer describing Unit from meter unit to Degree, minutes, second system using Data Flam property General Tag.



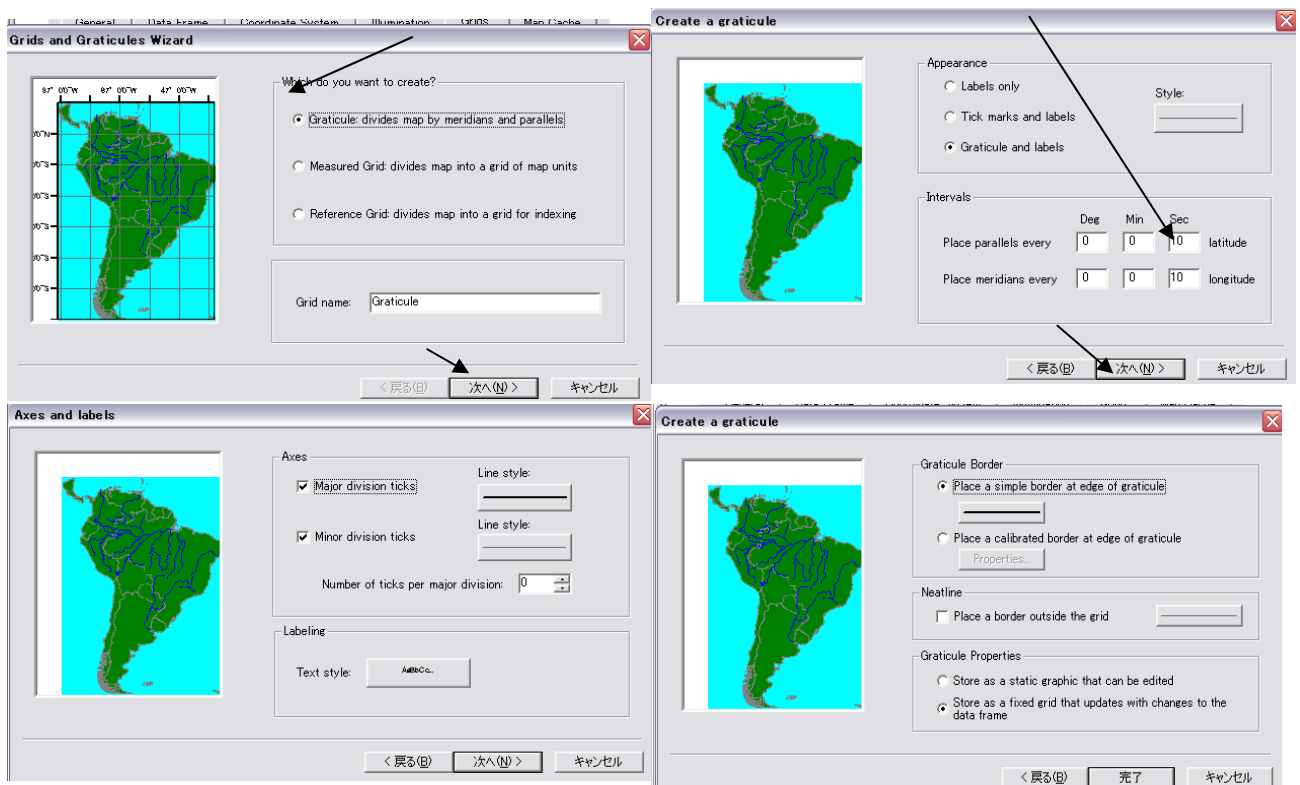
General: map delineation unit (Set as f Longitude and Latitude (Degree Minutes Second)

FID	Shape*	Id	COMP_ID	Area
0	Polygon	0	11	1664460
1	Polygon	0	10	1850308
2	Polygon	0	1	1240254
3	Polygon	0	12	1151979
4	Polygon	0	9	1195473
5	Polygon	0	2	915302

a.2 Open grid window using grid tag on the same data frame property.



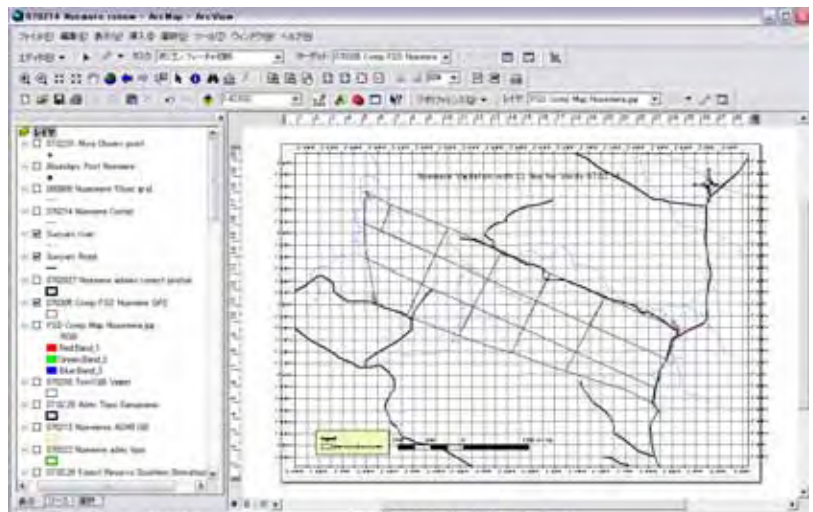
Then Grid wizard will come as below. Follow the instruction on the window. Mark on top line. , then click “Next”.



Key in unit for Longitude and Latitude (10 second for both); then, next computer asks how to delineate (Size and style of line, style of layer) Let try several patterns later. Now only crick Next (obey the original style).

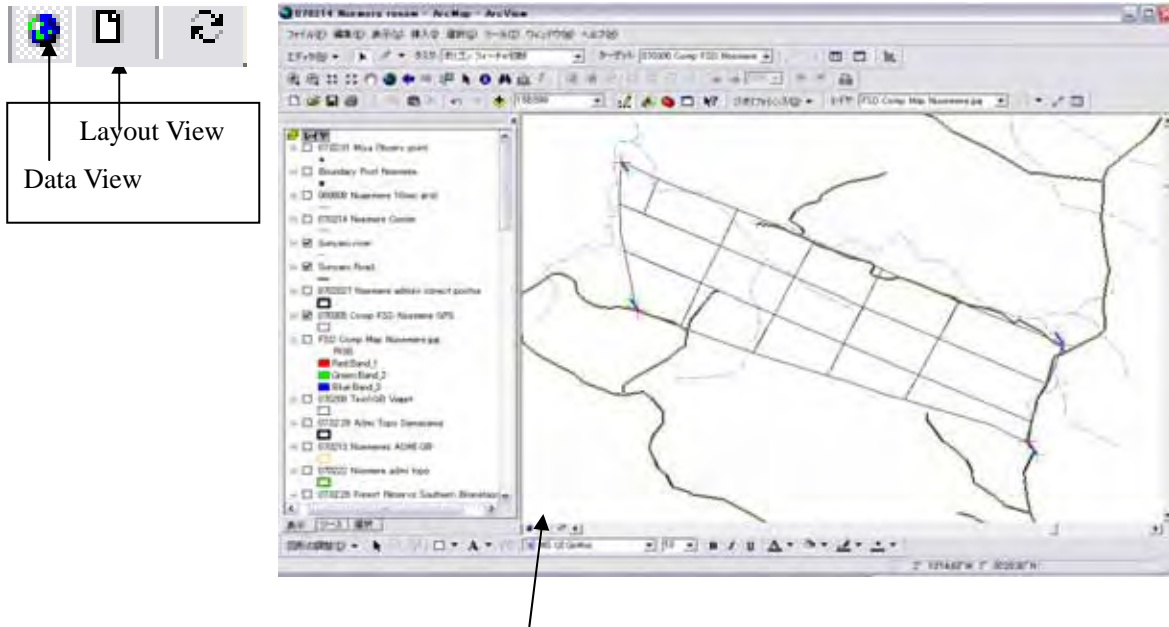
Then new window right picture will come. Click the button complete.

Grid system controlling procedures are set; the window will change same as started, but inserted a line, check mark on the line. If you want not describe LL line temporally, you erase the check mark on



this window.

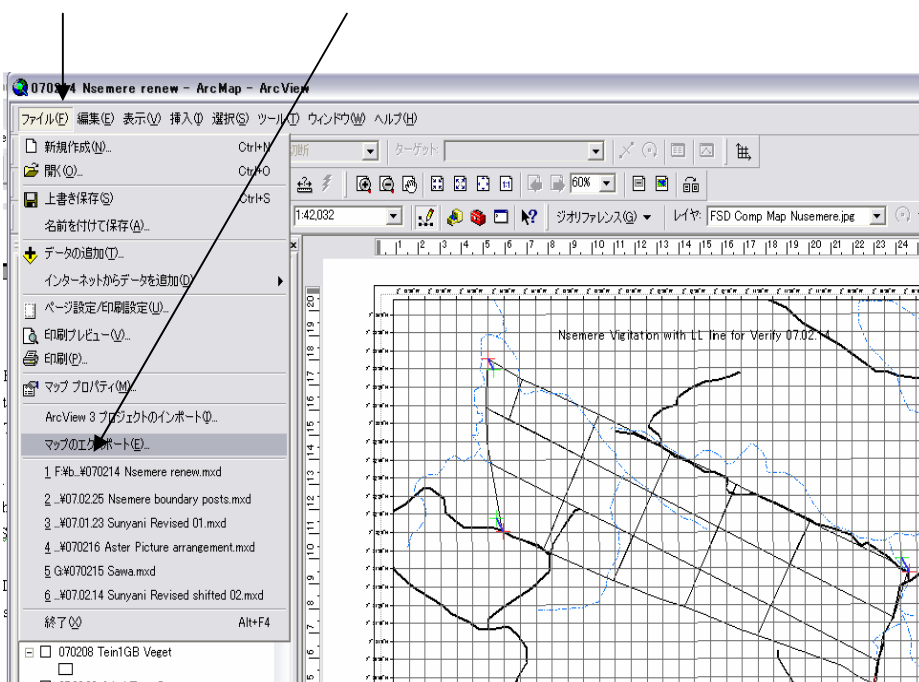
a.3 Change Arc map from Data view to Map View using below center icon left below part of the data View window.



Layout View sample: 10 second unit grid described map will arise on your computer screen.

a.4 Save this layout view map as a luster data to your folder as proper file name.

Export the map to your Folder under the name “Nsemere 10 sec grid map”, and renew the arc catalog. Then the Luster map files to Arc map.



Stop edit => Crick File => select Export Map within the pull down menu => give the file name and store on your folder.

(b) Making the 10 second unit line polygon as a new layer.

For the 10 second unit polygon making, you use a copied polygon of “Admi Nsemere” to a new layer “Parcel Nsemere” And divided a polygon on the layer “Parcel Nsemere” into 10 second units by tracing the luster map of “Nsemere 10 sec grid map”.

Preparation

a) Make a new layer file on Arc Catalog as named “Parcel Nsemere” (measuers are same as from (2) a. to d .
And put it to Arc Map.

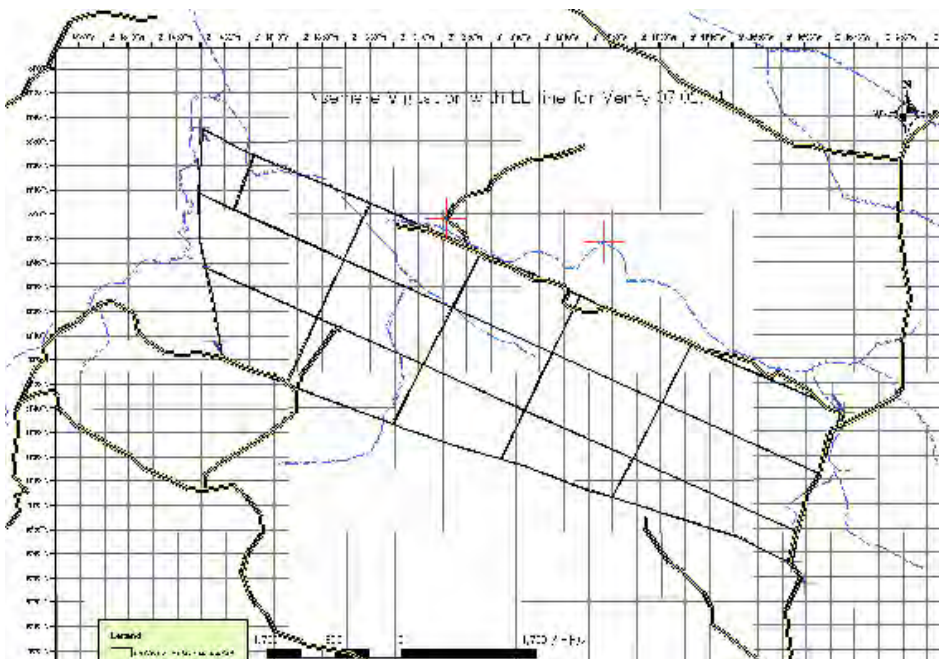
b) Insert Luster map “Nsemere 10 sec grid map” to Arc Map.

Open Arc catalog => renew the file name list in your folder => Drug and Drop the Luster map “Nsemere 10 sec grid map” and new layer “Parcel Nsemere” to Arc map.

c) Adjust the location of The Luster map “Nsemere 10 sec grid map” to “sunyani road” and “sunyani river” (base map of vector map). Measures of this adjusting is same process as mentioned before (See 3.1.e).



Following chart is adjusted the location Grid map to Base map.



You finish preparation for making new layer for Longitude and Latitude line polygon. This line polygon and label of the line (mark of Latitude and longitude) is effectively used for field verify to seek your standing point reading GPS and same point on the map.

(c) Make new layer file for Longitude and Latitude line polygon trasing LL line above (adjusted LL line luster map)

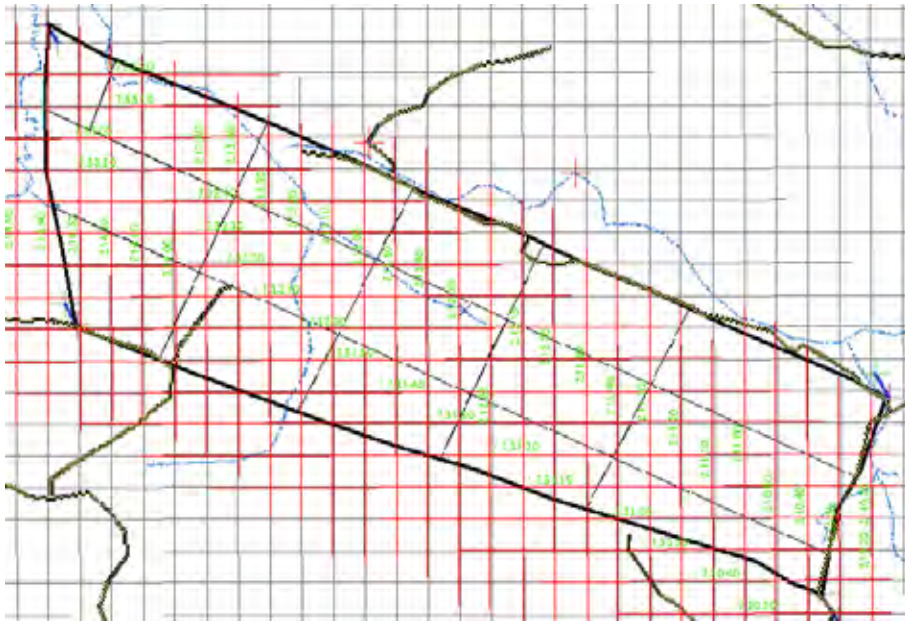
Open Arc Catalog => new file => give name "Nsemere Grid 10 sec", line polygon => import coordination system ("sunyaniriver") => Drag and drop the file to Arc Map => start editing => New feature "Nsemere Grid 10 sec".

Trace grid map lines and create line polygons for longitude line and latitude line.

(d) Give location data to data field on data table (Data Table management).

=> end the editing => open data table => add fields for Longitude, and Latitude => start editing => type in each line degree, minutes, second => save the edit => stop edit => open layer property => set label (formula as Long&":'"& Lati).

Red lines are new feature and labeled on each line for Latitude or Longitude.



b. Create new layer on 10 second union Parcels (Polygon).

Divide administration area into 10 second parcel using “divide polygon” command under the editing command list (pull down menu).

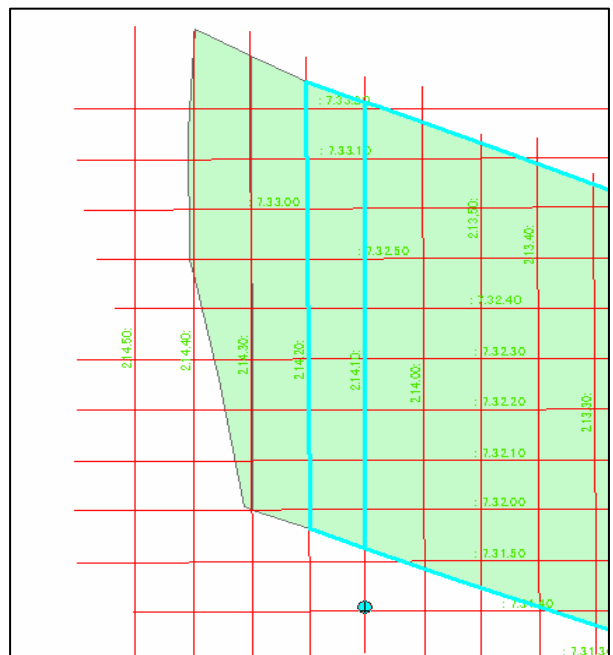
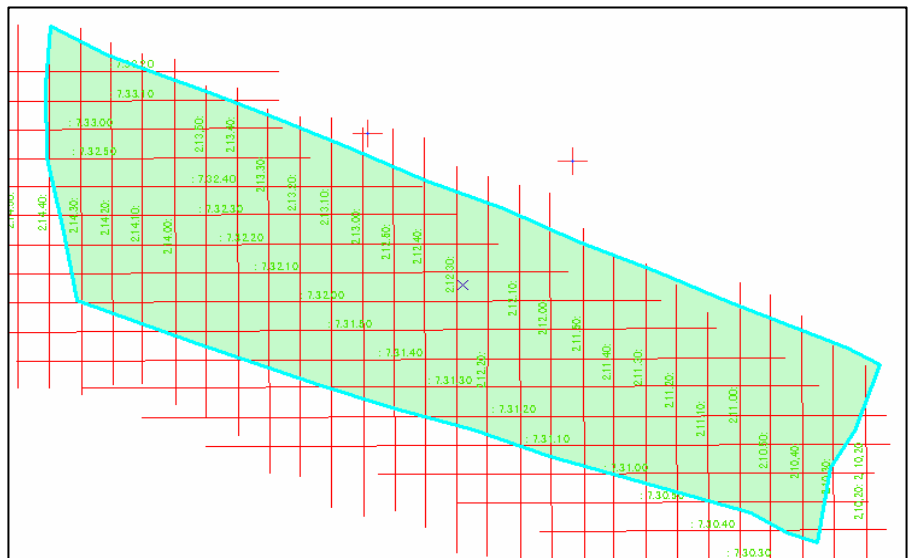
give check mark at “Parcel Nsemere GPS” on leftside layer list of Aerc

Map, then total administration area of Nsemere is described on your Arc Map.

Trace Latitude line and Longitude line (red line of the below figure like) using pencil icon.

Edit => start edit => set Task “Cut polygon” => set target “Parcel Nsemere GPS” => select a polygon => Trace a LL line using pencil icon == => repeat select a polygon and devide => edit => stop editing => save the edit.

The administration area had divided in to 10 second units parcels Polygons.



c Marge parcels into compartments.

Compartment polygon is made combining several Parcels above based on the 30 second latitude and 60 second longitude. Procedures are as follows.

Make a new layer for compartment on Arc Catalog (New file => give name (Nsemere 10sec comp GPS) and folder => select type (Polygon) => import coordination system (sunyaniriver) = apply the coordination system to “Nsemere 10 sec comp GPS” => Drug and drop the file to Arc Map => start edit on the target “Nsemere 10 sec comp GPS” => select all polygons of “Nsemere 10 sec parcel GPS” using related data table => Copy the polygons to “Nsemere 10 sec comp GPS” => select polygons on “Nsemere 10 sec comp GPS” to meet 30 second unit N-S 60 second unit E-W. => Marge selected polygons into a parcel => repeat same process for all compartment areas.

c.1 Use the land mark for compartment boundary first.

Compartment is also demarcate the area by natural land feature such as clear mountain ridge or river line; therefore, combining the parcels above, you need to observe the target area whether the typical land feature are recognized or not. If you find river line or ridge line, it is advisable to use these line for compartment boundary. if no typical land marks are found, compartment shall be set on Longitude and latitude line.

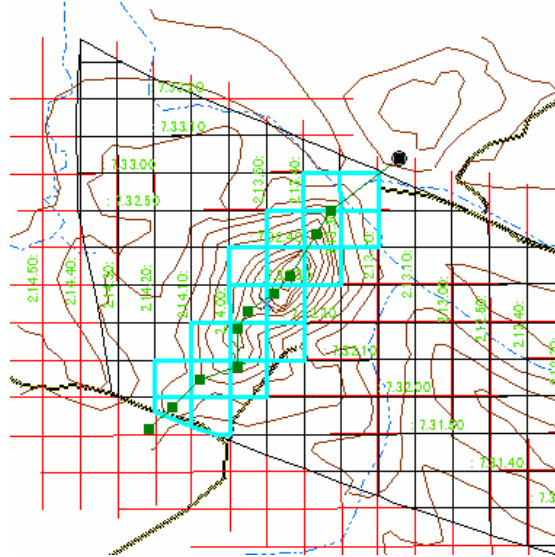
In Nsemere, a mountain stay in the northern part, and ridge line closing the reserve, therefore, this land mark shall be first to set compartment boundary.



Draw counter line used topographic map (luster map). Adjust the luster map to the Base map (vector map) location to “Sunyani river” and “Sunyani road” and trace the counter lines to a new layer for “Nsemere counter 50000”.

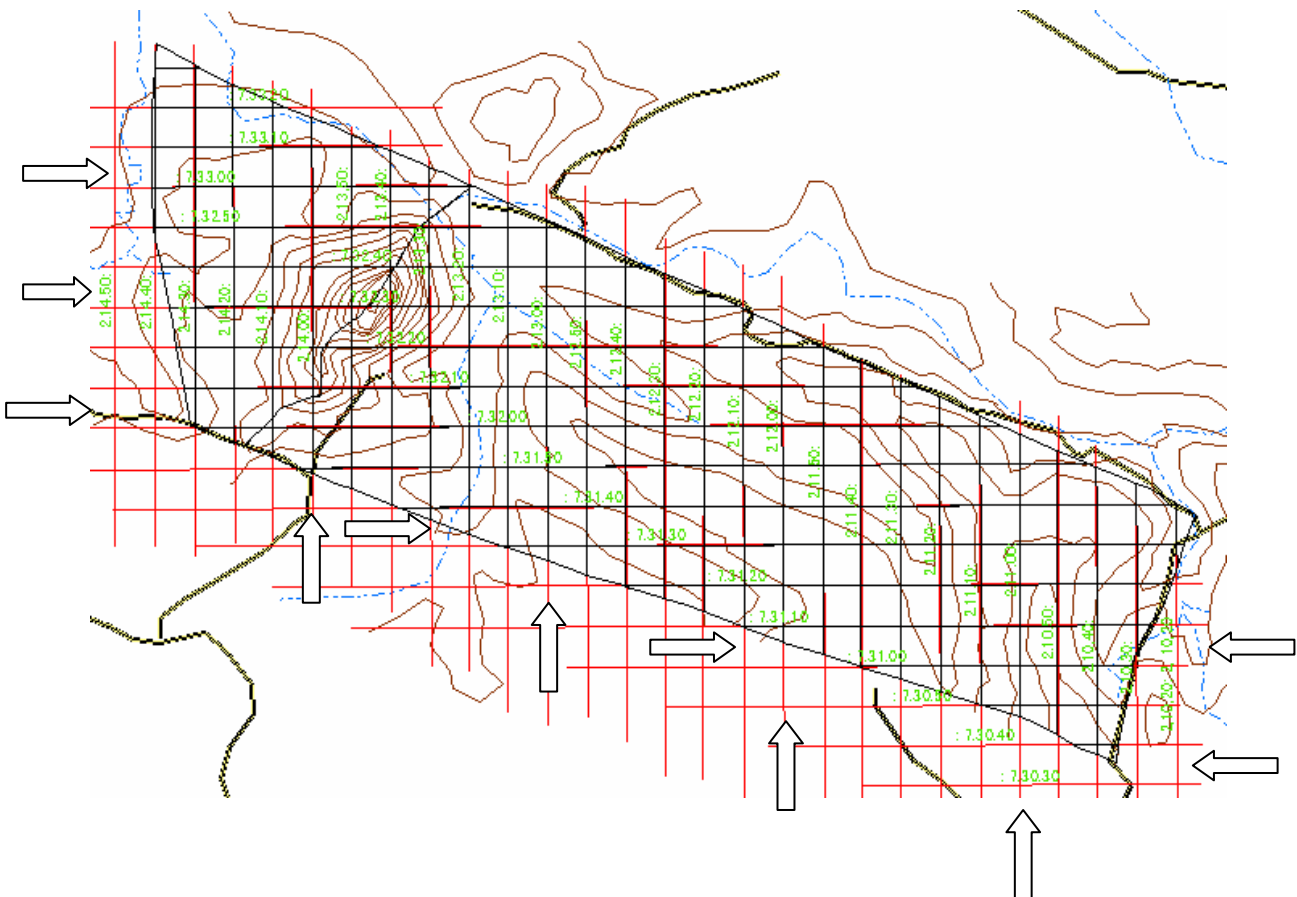
c.2 Divide 10 sec parcels with ridge line of the mountain/hill.

Start edit (target is "Nsemere 10 sec comp GPS") => Select parcels surrounding hill ridge line => Cut the parcels using pencil icon.

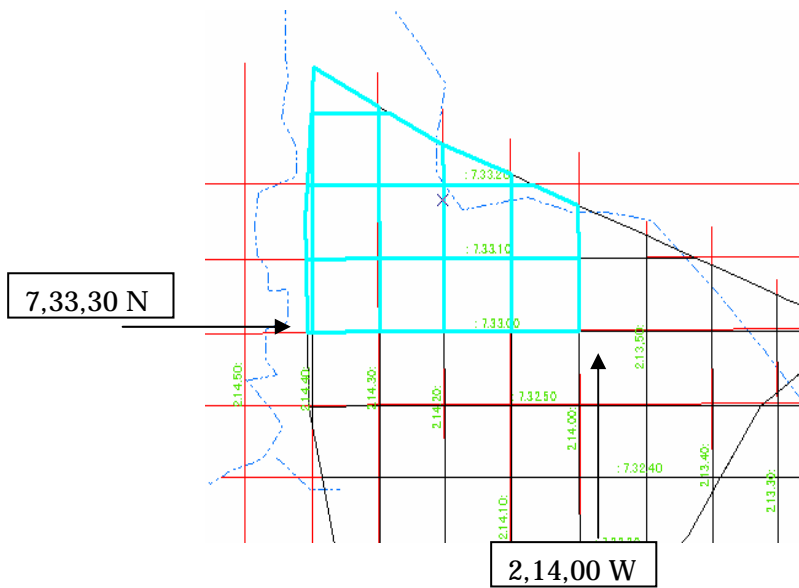


c.3 Decide compartment boundary setting line on where (Base degree for Latitude N-S, for Longitude E-W).

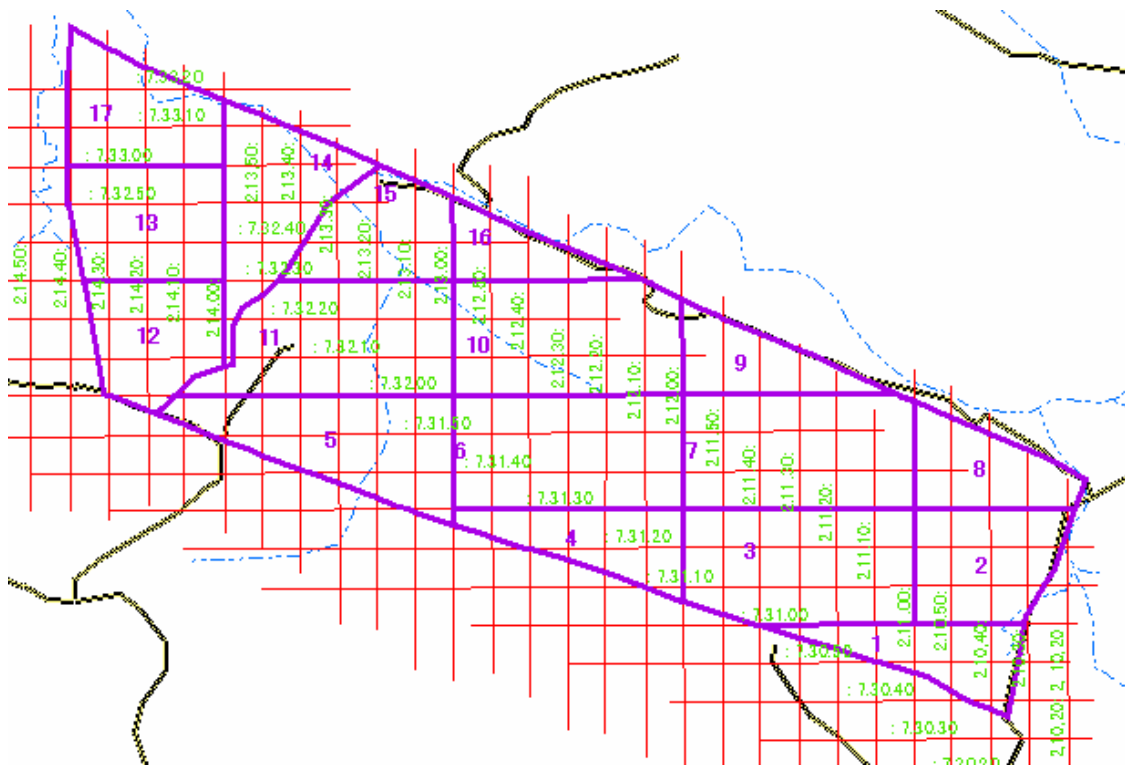
In this case, start from 7,30,00N 30 second interval for W=E, and from 2,11,00 W 60 second interval is used.



c.4 Select parcels within the square of area within the 30 second N-S, 60 second W-E units And merge the selected parcels to 1 polygon as a compartment using the merge command within the pull down menu of Edit.



c5. The demarcated compartment is follows; then, parcel No, compartment number shall be given to each polygon using data table.



Fields preparation.

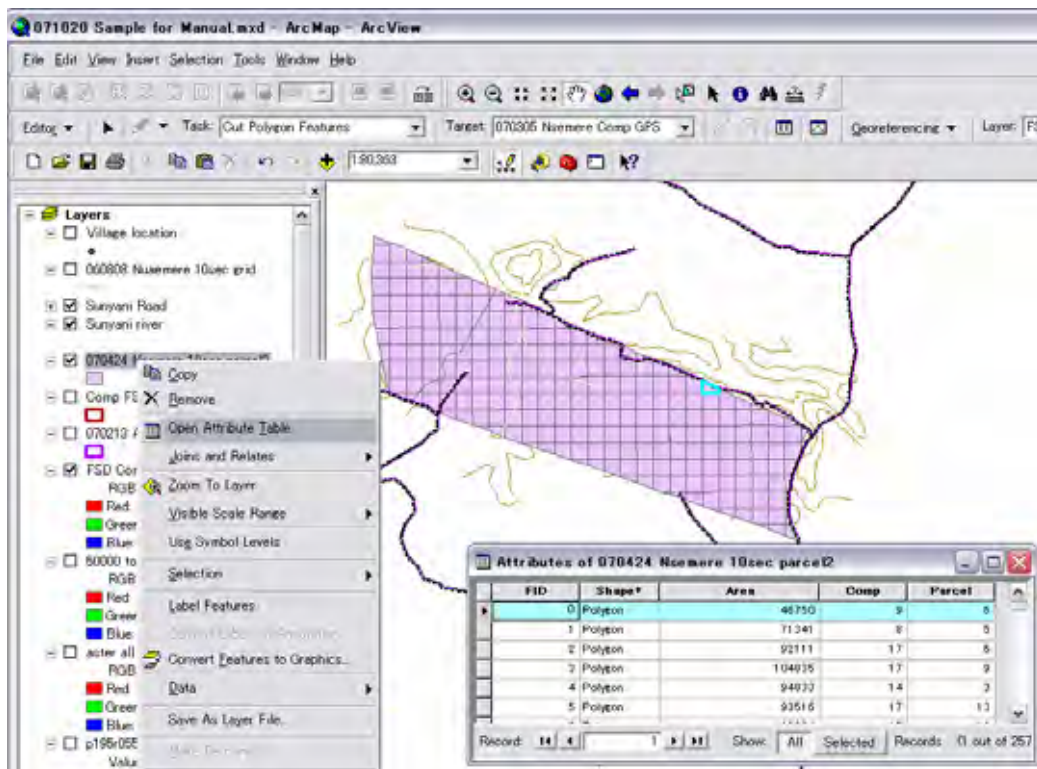
Edit => Stop Editing => Crick layer file name to call the data table => Crick option => add field => Give field name “CompID” => select type “short integer” => Give precision “10” => OK (repeat the process for needed fields making such as area (long integer 30), etc.).

- giving compartment No

c.5 Arrange Data table.

area, compartment No

Stop Edit => Open table => Option => Make new fields => field name, type, size => Start edit => type compartment No to field ID => calculate area calling the formula file => Save edit => stop edit.

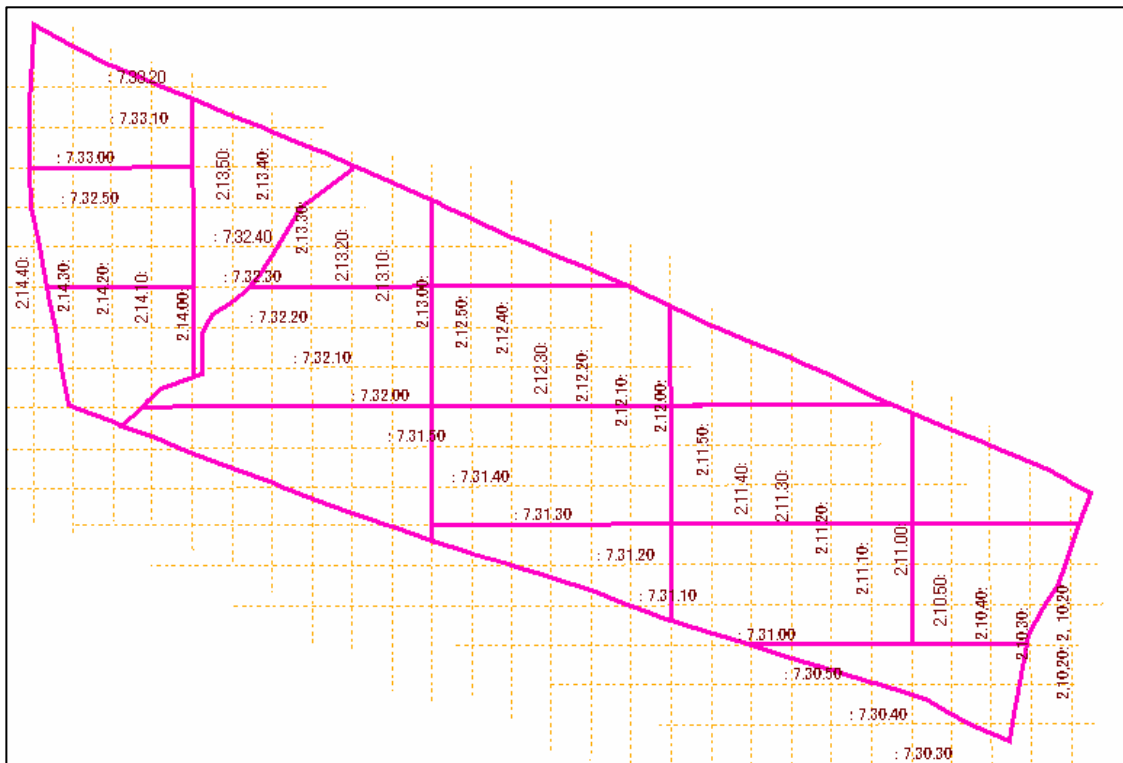


Right side table shows the result, giving compartment name, and calculated area.

The screenshot shows a table titled '属性: 070305 Nsumern Parcel GPS' with the following data:

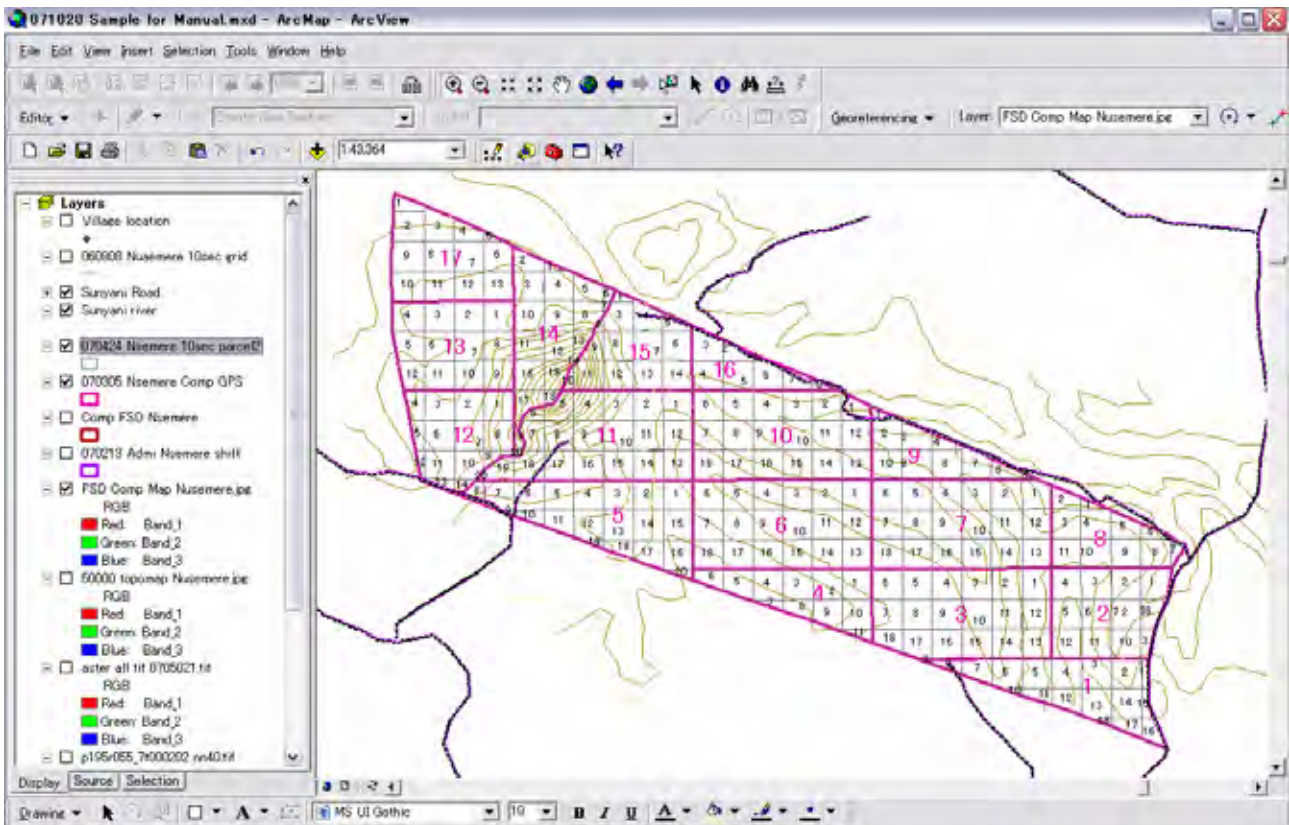
FID	Shape*	Id	area
0	Polygon	1	723290
1	Polygon	3	1660124
2	Polygon	2	1023692
3	Polygon	4	773803
4	Polygon	5	1414530
5	Polygon	6	1679901
6	Polygon	8	754980
7	Polygon	7	1687484
8	Polygon	10	940154
9	Polygon	9	654040
10	Polygon	11	1642761
11	Polygon	10	1664608
12	Polygon	16	-492818
13	Polygon	13	1100620
14	Polygon	14	1154621
15	Polygon	16	807560
16	Polygon	17	996107

Figure below shows Compartment system and Longitude, Latitude.



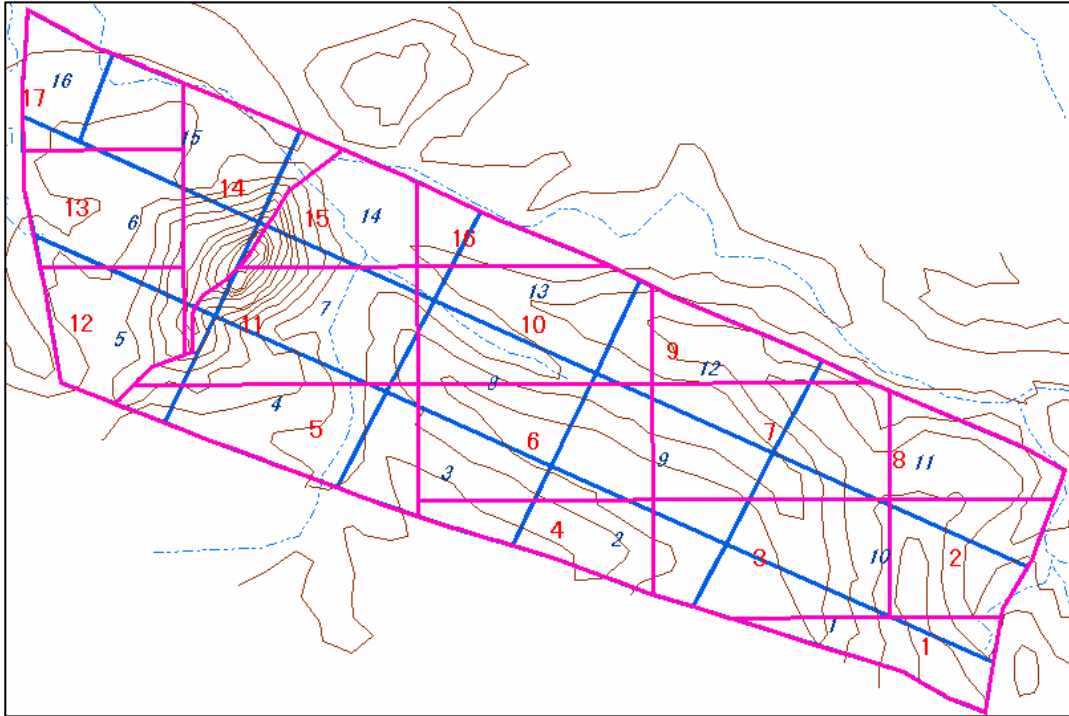
Then repeat to each parcel into parcel number. This number reflect as the addles of the each peace of land.

Every planning works in the Forest Management Plan can defined the location on the map as well as on the ground by the name of Compartment and parcel number. Figure below shows this addles system on the Arc Map.



Note: Check area table. If you find small polygons, it means you conduct something wrong. You have to find the small polygon, and merge to suitable compartment polygon. The number of the compartment is 17. Small polygons are never existed. Bugs removing measures are explained later chapter.

Following chart is comparison between existed FSD Compartment and new proposed one.

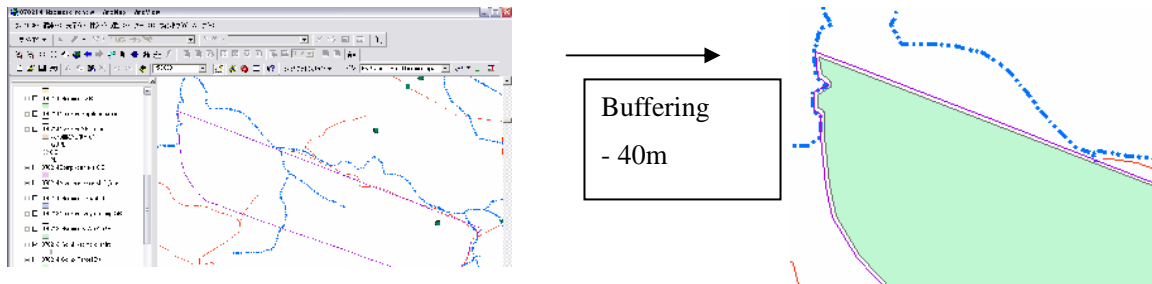


Sub-section D Preparation for Forest management Unit (Green Belt, Compartment)

How set up the area for Green Belt (40m width belt area from the reserve boundary) = Buffering.

1. Buffering for 40m width area from the boundary line.

Select “admi nsemere” polygon, and do buffering command from -40m., a layer excepted 40m area (Green Belt area) polygon layer is automatically made (named such as “Nsemere Plantation area”.

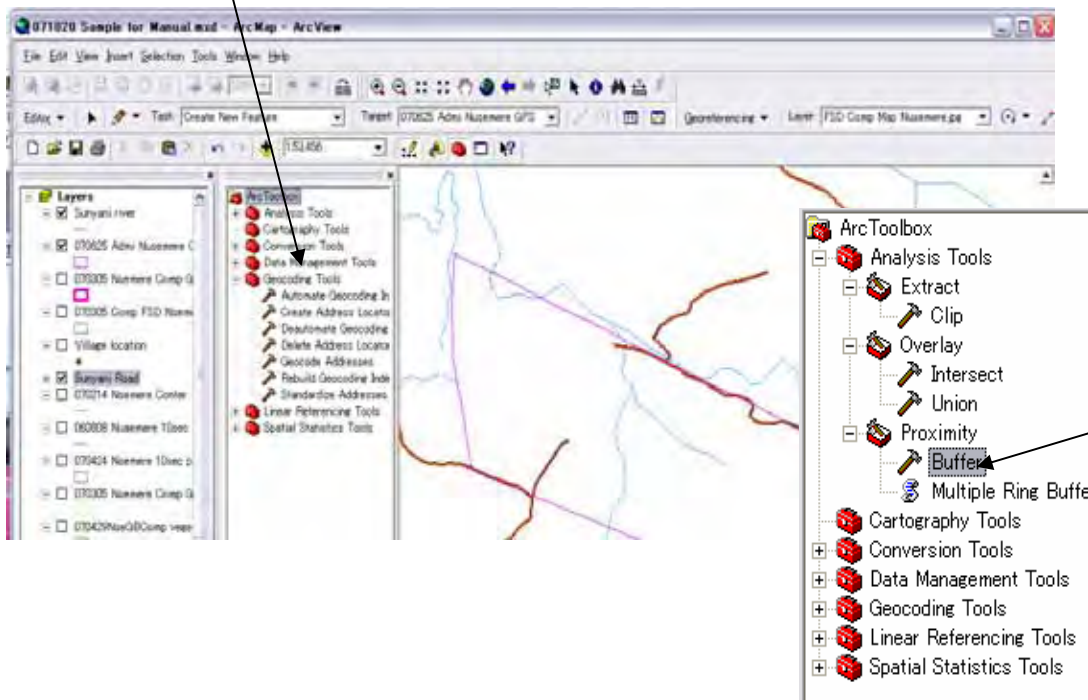


Crick tool box => then tools window come => crick Analysis tool =>Select Buffer => select single buffer (dabble crick) then buffering control window will come.

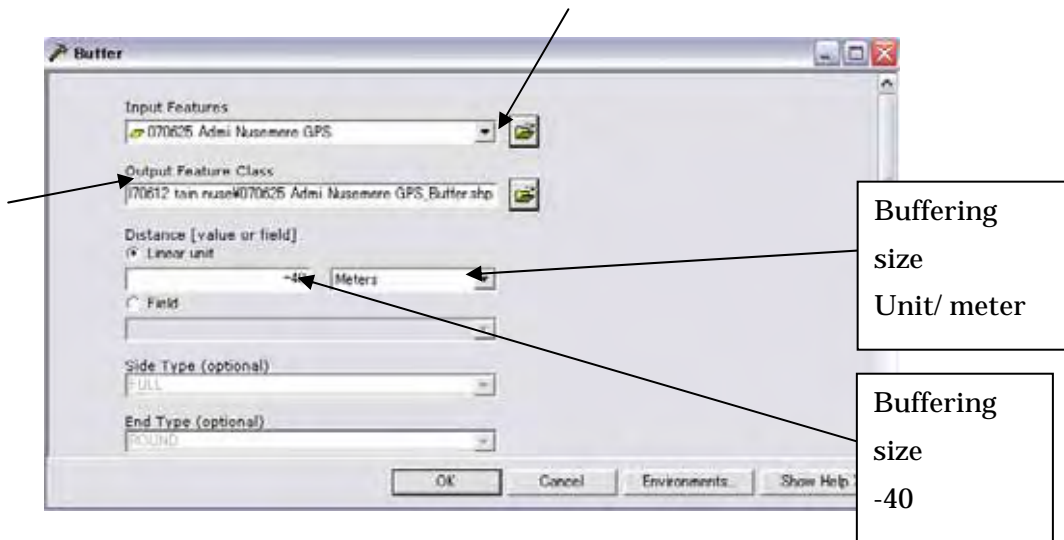


Tool Box Icon

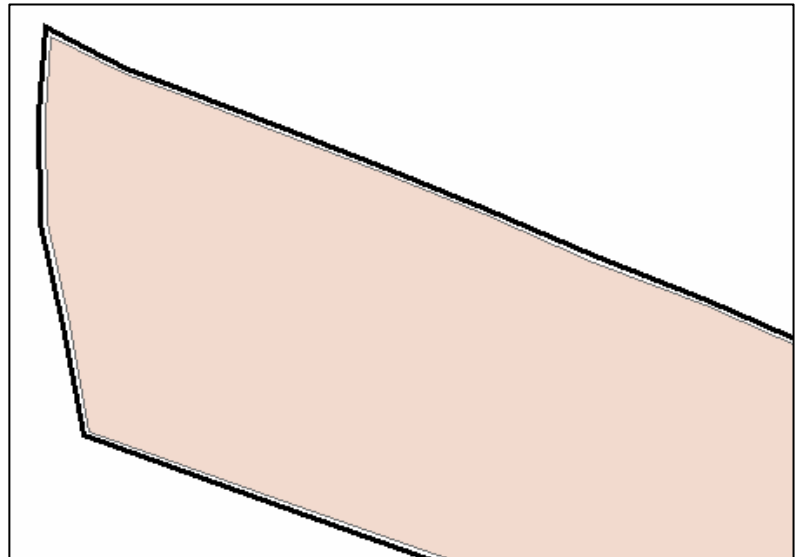
Tool Box window



- a. Select a target polygon (line or polygon file name: “admi nsemere GPS”) and a file name for out put (“Nsemere Plantation area”) with saving folder’s name. then “OK”.

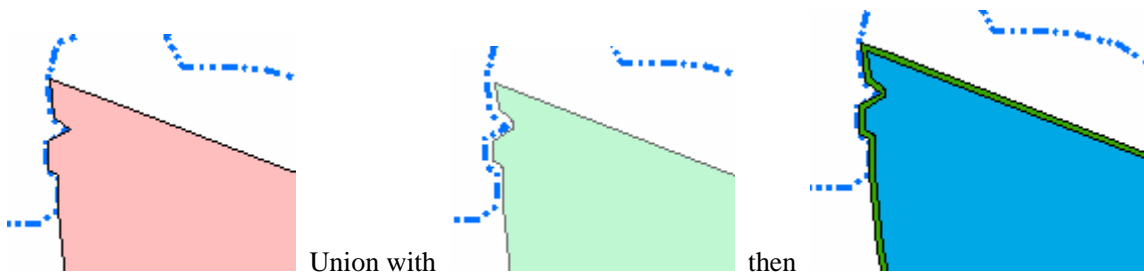


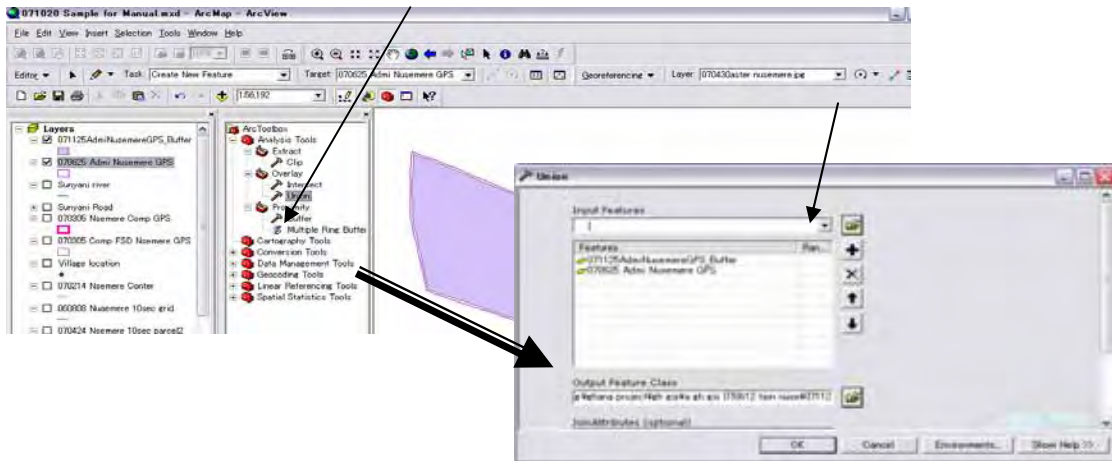
Then computer make a new layer delineated 40 m narrow area (except Green Belt area).



2. Delete the 40m inside area from total administration area for green belt area.

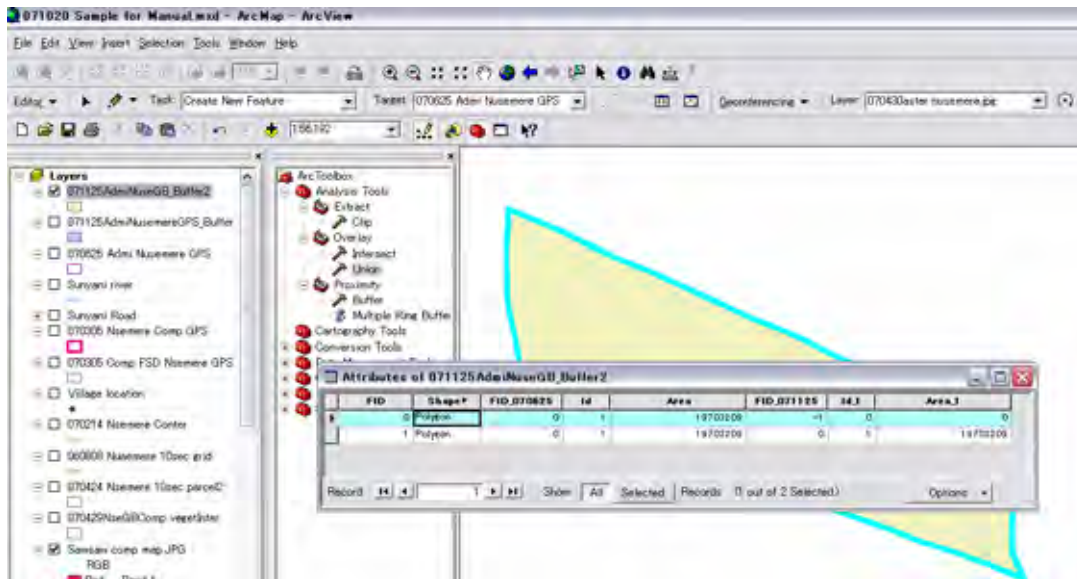
Intersect “admi nsemere” and “Nsemere Plantation area” using Geo-processing command. Then a new layer named “Nsemere GB and PL area” consist Green Belt area, and plantation area polygons on a layer. Then give the identifying cord GB and PL for each polygon on data table.





The data table unitized Buffer (-40m inside) and “Admi nsemere” area have fields both original fields of respected layers, therefore, arise fields unnecessary or duprocate. And add a field for polygon identification for Green belt area(GB) and Plantation area (PL). Give the code GB and PL to each column of the polygon. The arranged table is shown as above.

Open table => stop edit => add field as “PL GB” (on text 5 letters column size) => start edit => calculate area => give PL or GB on the new field.

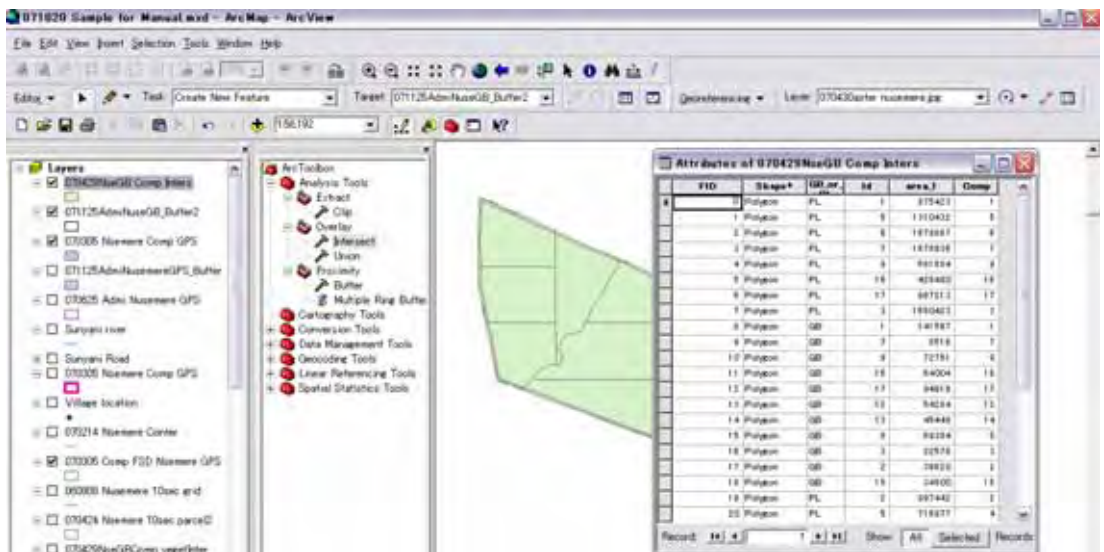
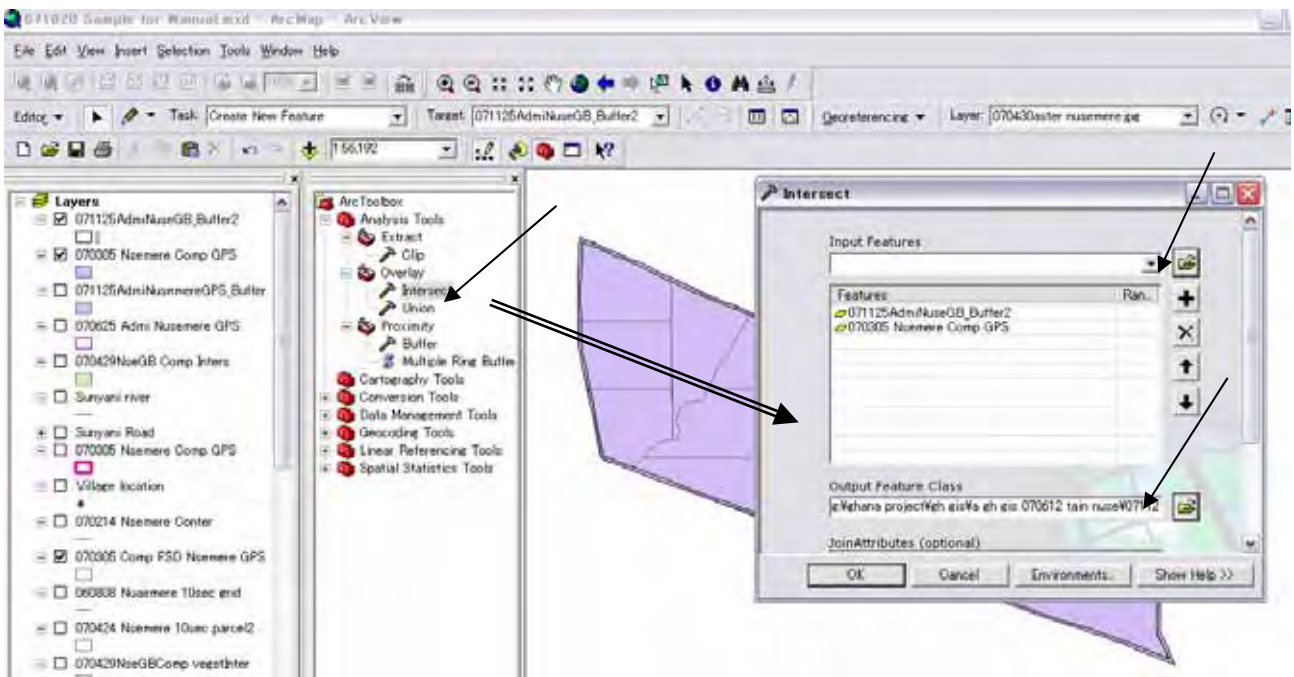
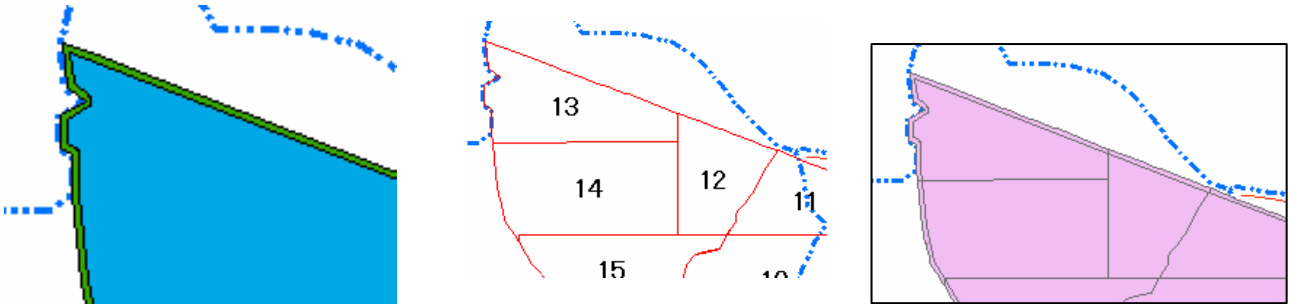


FID	Shape*	FID_070625	Id	Area	GB_ID
0	Polygon	0	1	880973	GB
1	Polygon	0	1	1882236	PL

3. Every Compartment areas shall be divided into Green Belt area and Plantation area.

a. Intersect Compartment layer and Nsemere GB and PL area layer using Geo-processing command. Then a new layer shows divided each compartment into Green Belt area and Plantation area.

Intersect both as below.



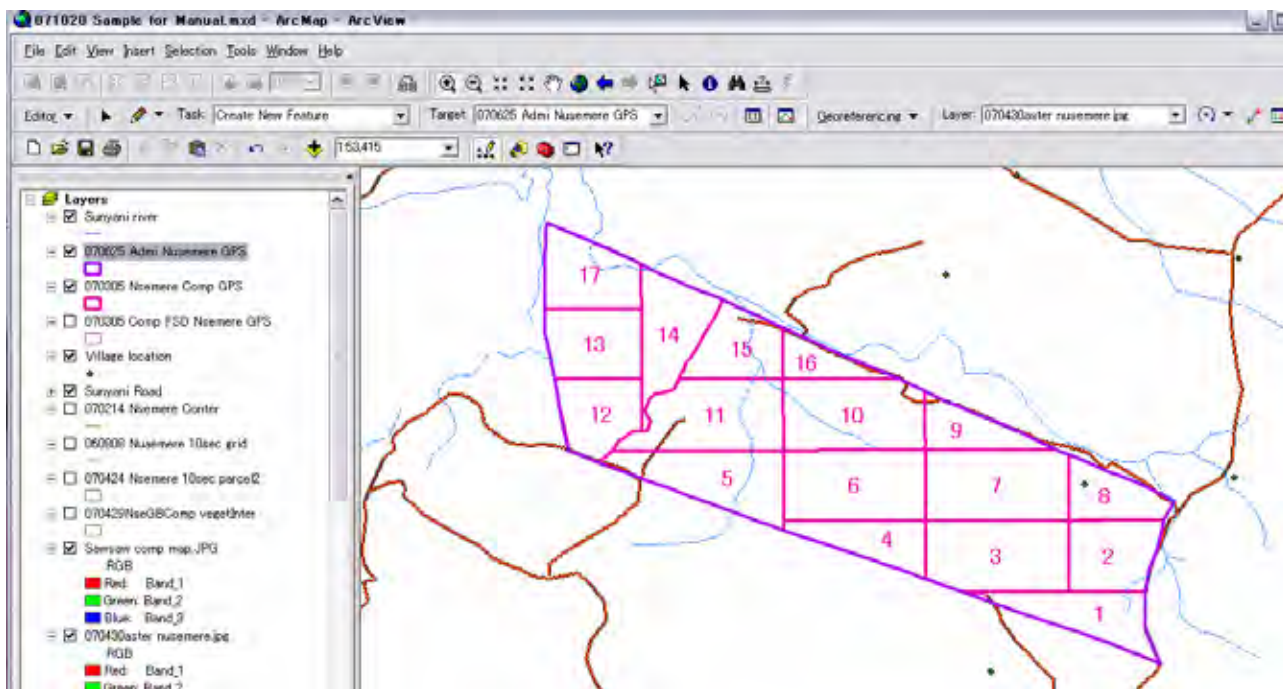
Then Green Belt area and Plantation area are divided into compartment. Call the attribute table and arrange fields.

Calculate areas of every polygons. Then you can get the table shows above.

Procedures are as follows:

Put the files “Nsemere 10 sec comp GPS” and “Nsemere GB and PL area” on top position of the left side of the Arc Map file name list. => call Arc Tool => crick analysis tool => Crick Overlay => Crick Intersect
Do not forget the name mentioning for exporting (“Comp GB Nsemere”).

The final out put is following.



The green belt area and plantation areas are divided into compartment system.

You prepared for making vegetation/forest type map and arranging the Forest Inventory book.

Section 3 GIS Arc Map for making Vegetation Map

Now we finish the preparation for Management unit compartment polygons on the Arc Map. Next job is the core part to analyze latest forest situation. Generally, foresters always grasping his responsible area, recorded every compartment, sub-compartment situation such as when it was planted, what species are growing, when it will be harvested and replanted. Nevertheless, many countries facing difficulties to do same as ideal because of limited man power, limited resources for surveying patrolling. Some case un-planned/illegal logging, wild fire, natural disaster give damages forests, and forester can not hold the real situation. Forest area is so large, to observe the areas may needed months and years. The satellite data is expected to help foresters field observation in wider area in shot time.

This section is introducing the methods how to use satellite imagery for analyzing the expansion of forest/vegetation areas and fix the position on map, and calculate areas under the forest management unit such as compartment system.

The measures/procedure satellite image arranged for forest management planning are roughly follows.

- a. get latest satellite imagery (In this manual Aster data is used).
- b. Put the aster data on Arc Map (arrange the coordination/position).
- c. Delineate similar patterned areas as polygon.
- d. Field vilify for finding significant meaning the area shows on the satellite imagery.
- e. Define vegetation types reflecting to the typical patterns of the satellite images.
- f. To intersect compartment polygon and vegetation polygon.
- g. Calculate area by compartment/sub-compartment.
- h. Order the calculate result as a Forest Inventory Book (compartment, sub-compartment, vegetation pattern).
- i. Add existed data to Forest Inventory Book such as main tree sepsis, planted year/age, crown density, stand number/ha, special plan or animal living, existence of traditional use by the surrounded communities, etc. etc.
- g. To present the forest Inventory Book to the responsible planning units of FSD for Forest Management Plan formulation.

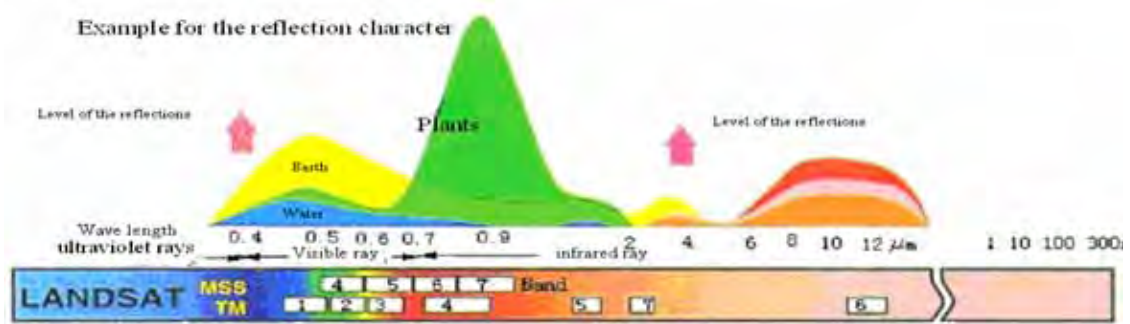
This section mainly explain the procedure operating Arc View for a to g above, and h to g will explain on the next section.

1. What kind of Satellite data shall be used.

There are many satellites around the globe. Typical are Land Sat, Aster , Spot, etc. etc. The resolution of the satellite is deferent. Covering area by a sheet (picture) is deferent. Price is quite deferent.

In this manual, author selected “Aster” because of the price level and vegetation condition of the target area (Sunyani district Ghana, not high complex of forest, not complicated land feature).

Satellite data consist with several band pictures. Following a figure explains that Band 4 of TM shows much reflecting for the amount of the plant (leafs of the plant).



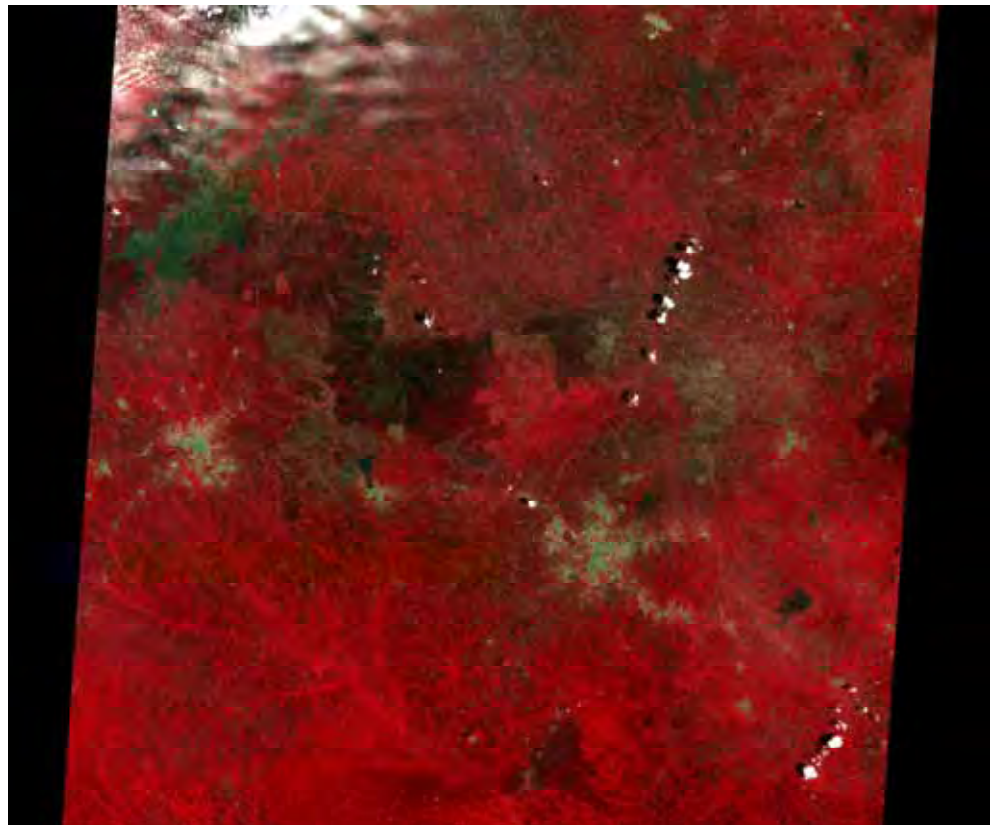
Red 1, Green 2, Blue 3 band

Red 1, Green 4, Blue 3 band

Red 4, Green 3, Blue 1 band

2. Put satellite image (Luster data) into Arc Map made through previous section

Original data was prepared as a Luster data file (Processed for vegetation analyzing).




The size of Aster picture is too large, therefore, part of above picture covering typical land feature (road, river) surrounded the target forest reserve Nsemere as below. Cutting the picture was done using Photoshop (Adobe).

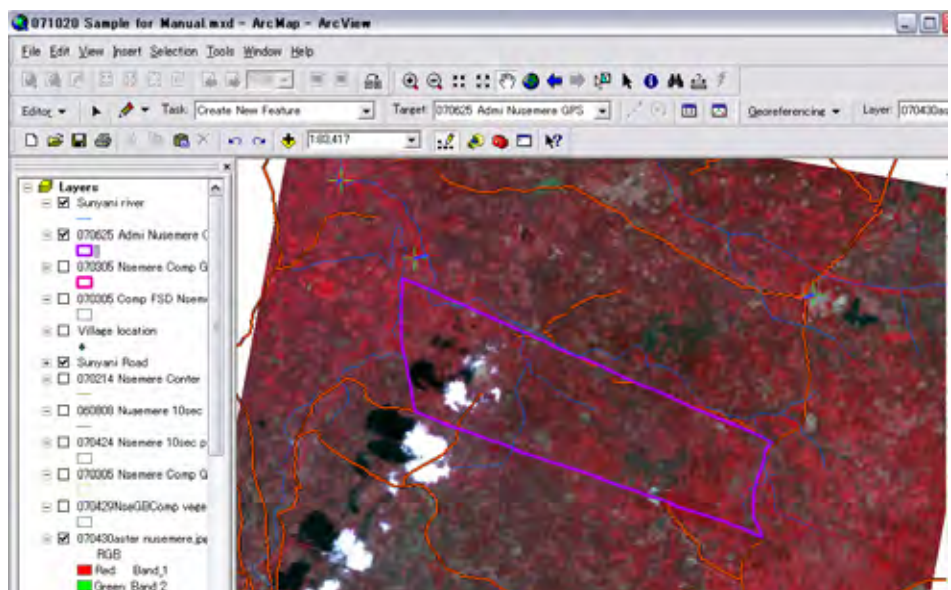


a. The above Luster picture shall be adjusted to the base map.

Procedure is same as topographic map to base map explained on sub part A.

Open Arc Catalog => click a luster file “070430 Aster Nsemere” => drag to Arc Map => give check mark to files on 070430aster nusemere, “river sunyani”, “road sunyani”, and “admi nsemere” => harmonize the described area of Base Map and Aster Nsemere => set georife070430aster nsemere => crick georigerence tag => Fit to display.

Then adjust aster nsemere to Base map using  icon => open georeference Link table => save the table (give a file name for example “fix point 070430 aster nsemere” on the same folder that the file “aster nsemere” stored.



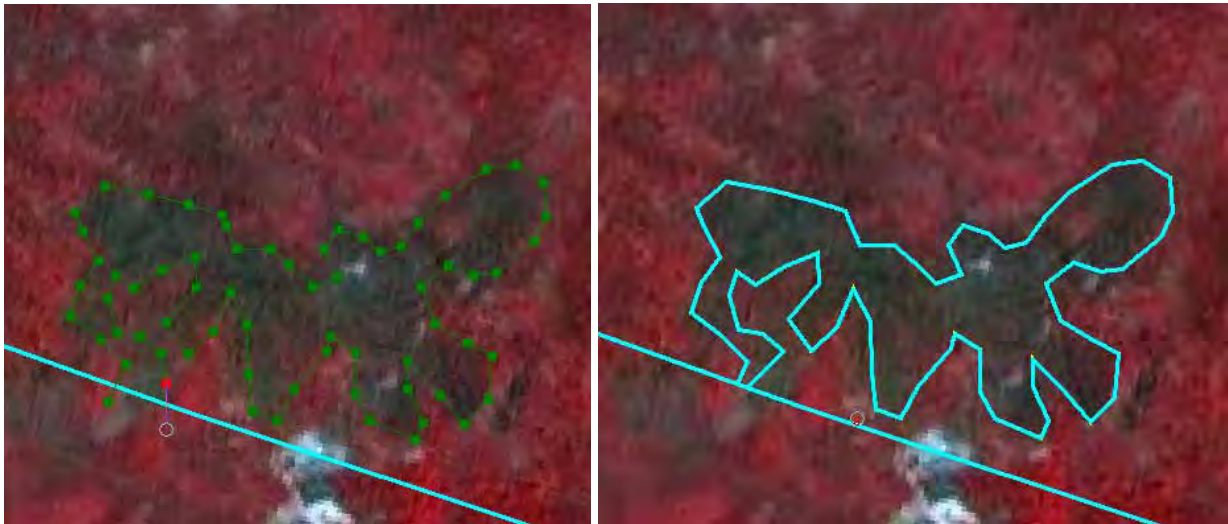
3. Demarcation for similar patterned areas as a polygon.

First you have to prepare a new layer “Veget Nsemere” for vegetation polygon writing, then copy “admi nsemere” for target area fixing to the layer of “Veget Nsemere”. The vegetation map is made dividing the total target area (admi nsemere) into vegetation type reflected areas.

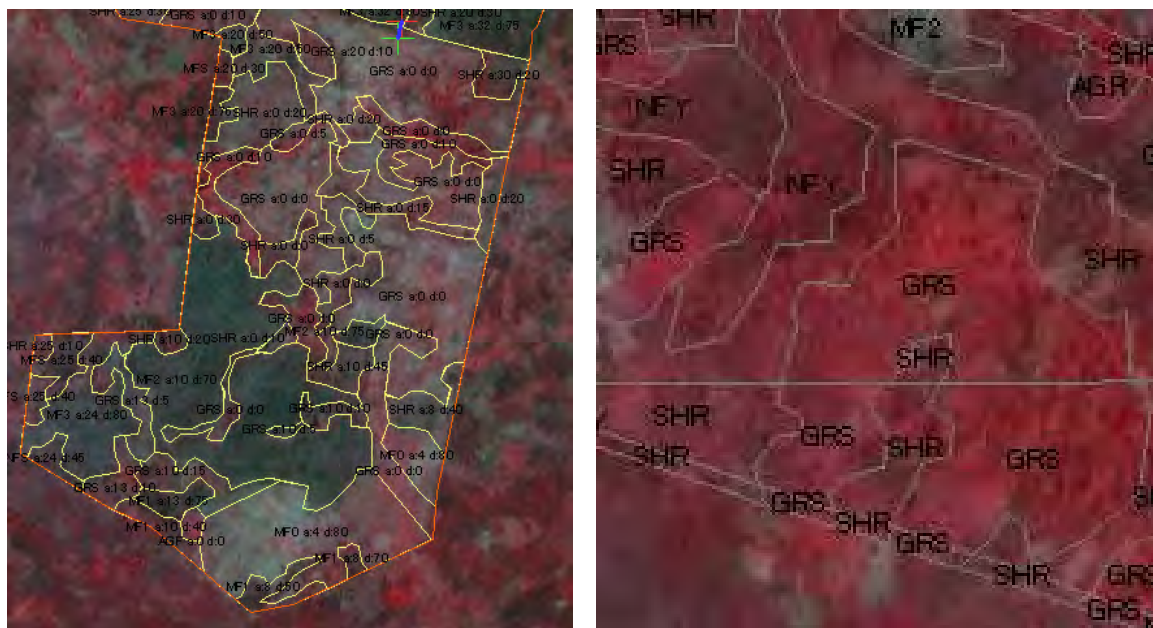
Open Arc Catalog =>File => New => Shape file => name of file “Veget Nsemere” => Type “Polygon” => Edit coordination => Import (river nsemere) => apply => drag and drop “Veget Nsemere” to Arc Map

On Arc Map mark on file “Veget Nsemere” => Edit => Start Editing => set task Create new polygon => set target “Veget Nsemere” => Select a polygon from the layer “admi nsemere” => copy => erase check mark of the file “admi nsemere” => Past to the layer “Veget Nsemere”.

Then you finish preparation for delineating the vegetation polygons.



Find Teak forest reflecting patten, and demarcate area for a polygon




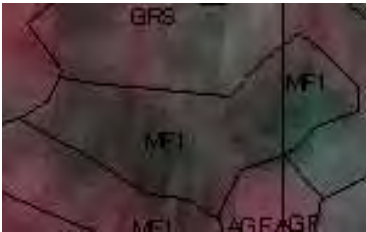

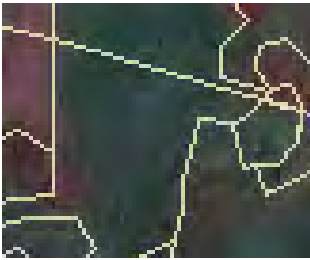
Select a polygon => cut the polygon in edit tool => trace the similar area from a point cross the selected polygon outline to other point cross of the selected polygon out line.


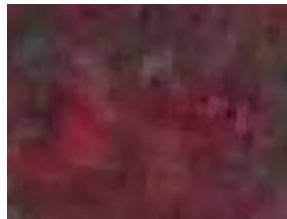

Samples of typical pattern of satellite Aster images reflecting to the vegetation type

Generally, satellite image is reflecting something on the land surface character; you need to find relation which pattern shows what type of forest/vegetation. Before vegetation delineation on Arc Map, you visit real fields and observe what kind of vegetation type exist on where, then to compare your knowledge about real fields.

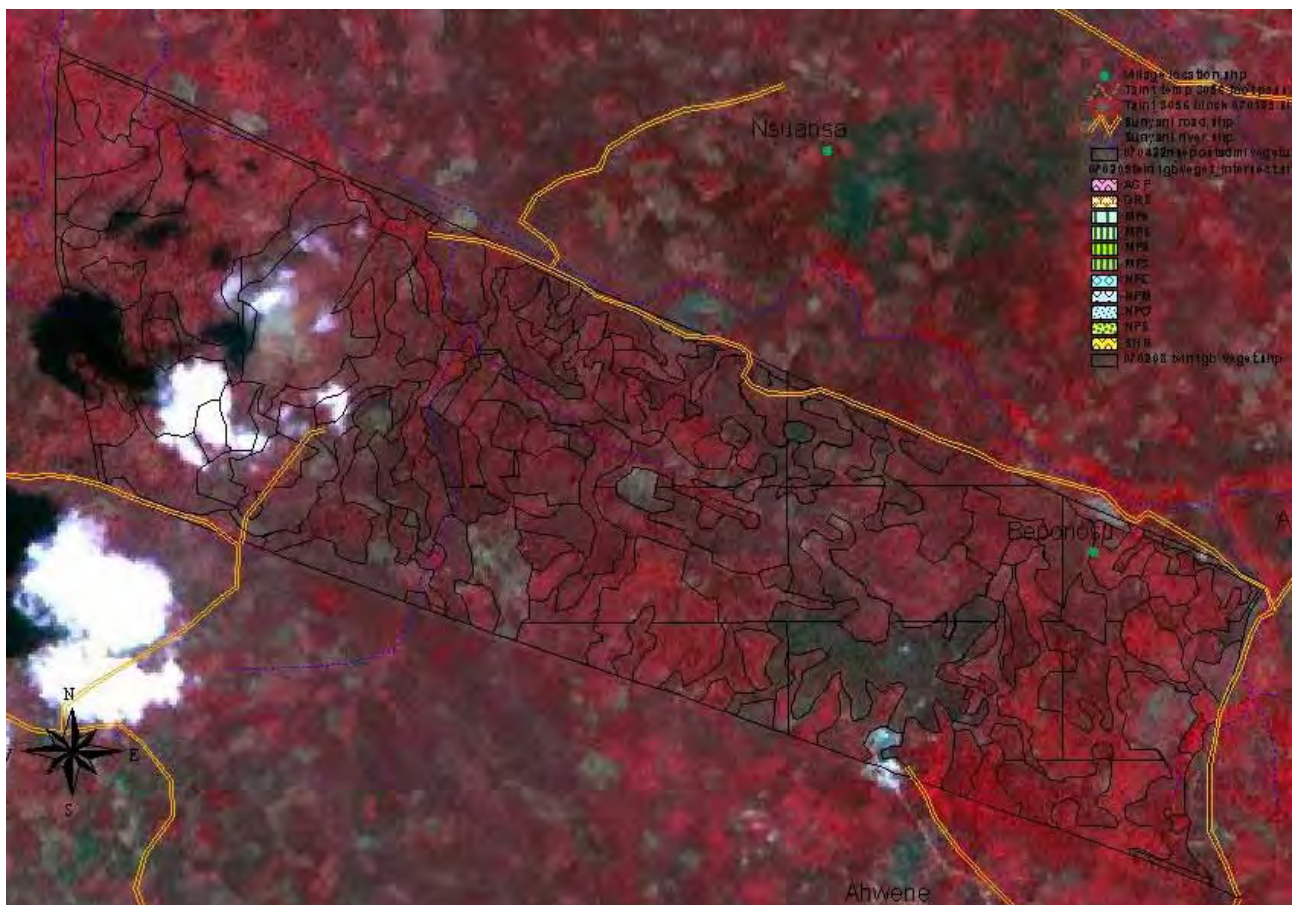
You make some standards how to interpret the satellite image to vegetation type.

Followings are sample that the author found such relation on the field study on Tain 1 and Nsemere area and Aster Satellite image. To apply this process on other area, by other sheet of Aster picture, you have to make these standards to meet real field situation and Aster data feature (Color pattern may difference picture by picture because of different natural/ sky conditions on the satellite photo shot time).

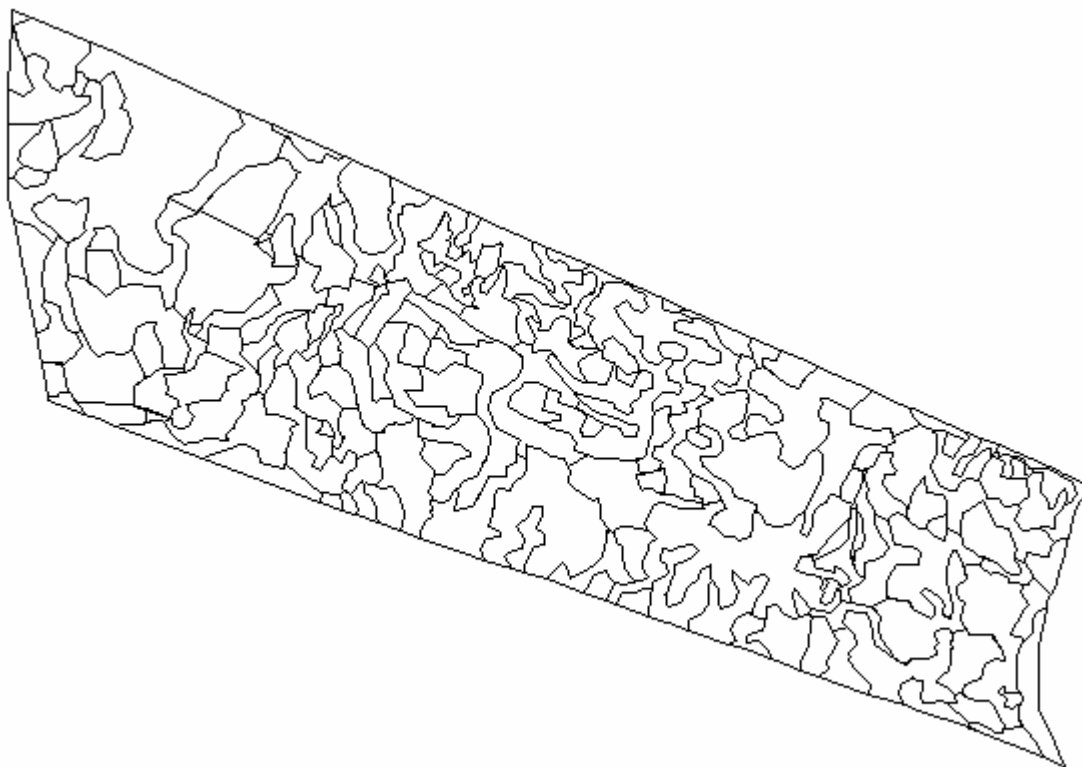
Forest type ID	Typical Pattern	Explanation
Open natural forest		Crown of the top and middle layer covered less than 10%.
Teak forest 1		Age 6-15 reached to closed condition by crowns. Dark green and dark red are mixing, partly open places are remaining.
Teak forest 2		Age 15-20 reaching to thinning age. Satellite images are similar with above, therefore, decide from planted records.
Teak forest 3		Age 20 or more, reaching to harvesting age.

Forest type ID	Typical Pattern	Explanation
Grass land		Grass covered, and crowns of high tree or shrub tree covered. River side grass land occasionally flooded.
Farming land		
Shrub area		

Then target area divided into vegetation type/Forest type are as follows.



Finally, you will get following polygons on the layer “Veget Nsemere”.



Next job is give a code and other information to each polygon such as vegetation code, age, species, crown density, and other factors you needed. These data you can obtain from your Forestry related offices or field survey.

The data is type in on the attribute table of the layer.

Call attribute table of the layer.

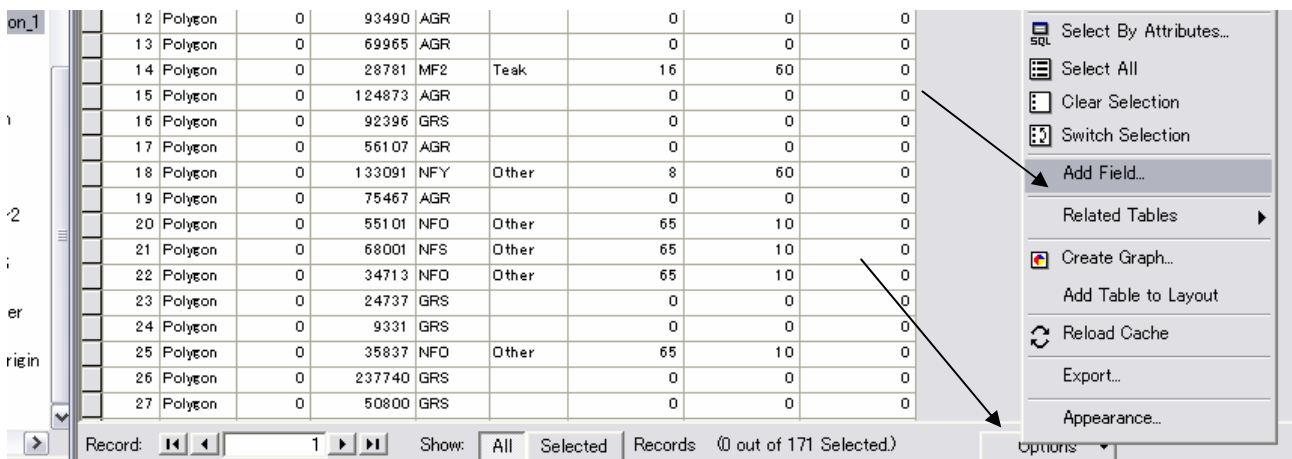
Right crick on the layer => Open attribute table.

Attributes of 070422NsePostadmiveget union_1

FID	Shape*	Id	area	F_Type	SPP	Age	C.dence	Sub_G
0	Polygon	0	63764	SHR		0	0	0
1	Polygon	0	538653	GRS		0	0	0
2	Polygon	0	270208	MF1	Teak	8	60	0
3	Polygon	0	65783	SHR		0	0	0
4	Polygon	0	157175	MF2	Teak	16	50	0
5	Polygon	0	108087	GRS		0	0	0
6	Polygon	0	17246	AGR		0	0	0
7	Polygon	0	45945	AGR		0	0	0
8	Polygon	0	56128	AGR		0	0	0
9	Polygon	0	54058	AGR		0	0	0
10	Polygon	0	163131	GRS		0	0	0
11	Polygon	0	168923	AGR		0	0	0
12	Polygon	0	93490	AGR		0	0	0
13	Polygon	0	69965	AGR		0	0	0
14	Polygon	0	28781	MF2	Teak	16	60	0
15	Polygon	0	124873	AGR		0	0	0
16	Polygon	0	92396	GRS		0	0	0
17	Polygon	0	56107	NFY		0	0	0
18	Polygon	0	133091	NFY	Other	8	60	0
19	Polygon	0	75467	AGR		0	0	0
20	Polygon	0	55101	NFO	Other	65	10	0
21	Polygon	0	68001	NFS	Other	65	10	0
22	Polygon	0	34713	NFO	Other	65	10	0
23	Polygon	0	24737	GRS		0	0	0
24	Polygon	0	9331	GRS		0	0	0
25	Polygon	0	35837	NFO	Other	65	10	0

To arrange attribute table for making the fields for Forest type (F_Type: text), Area (long integer), Compartment (Comp short integer), sub-compartment (S_comp short integer), Age (short integer), Species (spp: text), Crown density (C Dence: short integer), Planting area or Green belt area (P_G text).

The field making is carried non editing condition, if the arc map moving under the editing condition, end and save existed editing. Then crick Options button on the bottom right side of the attribute table. And select new field making. Type in Name of the field width of the column or select, data type (short integer , long integer, or text).



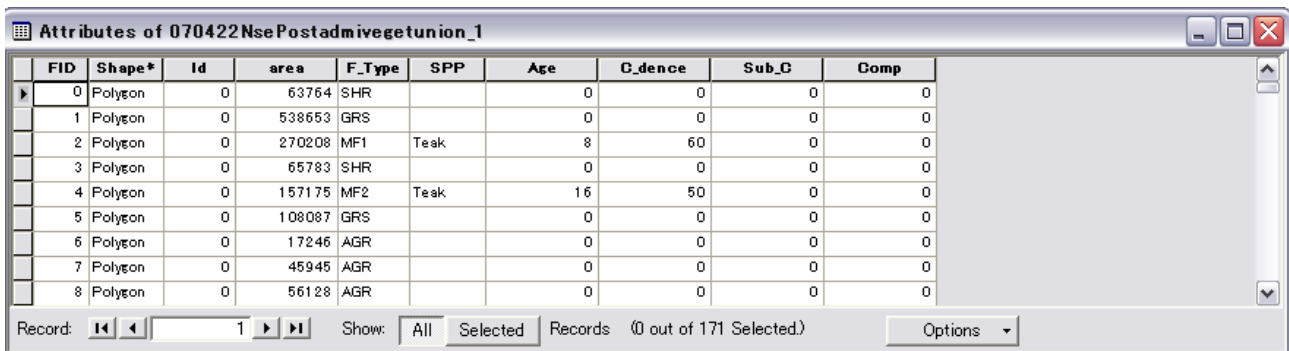
Then start edit. Crick start edit edit => set target layer (Nsemere aeget)

First calculate area of each line (polygon). Right crick field name “area” => crick calculator icon => load area calculation formula => OK

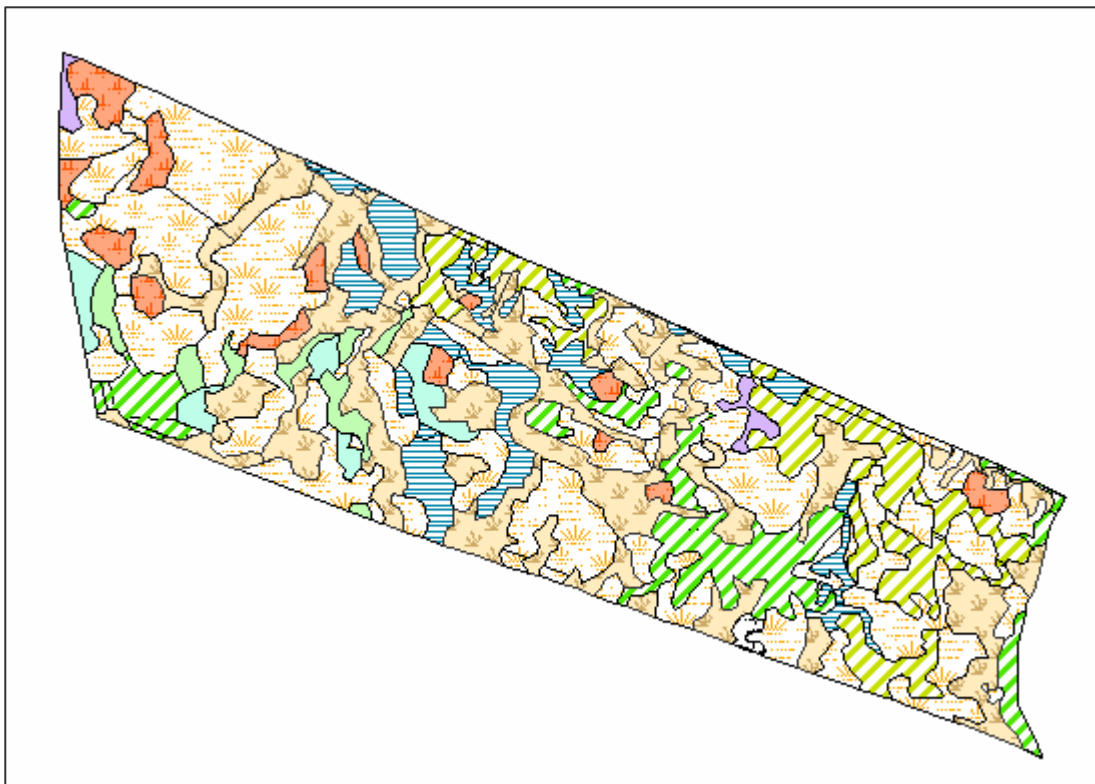
The field area of each polygon will filed automatically number. Sort the area from small to large, if you find area “0” or very small, this shows there are many irregular polygons remain. Amend the polygons one by one. The works for removing these irregular polygons is one of unwelcome work, nevertheless, it shall be done. Methods are shows on chapter 5 of Section 6.

Then, you start filling data to fields of each line based on your field survey or data collected.

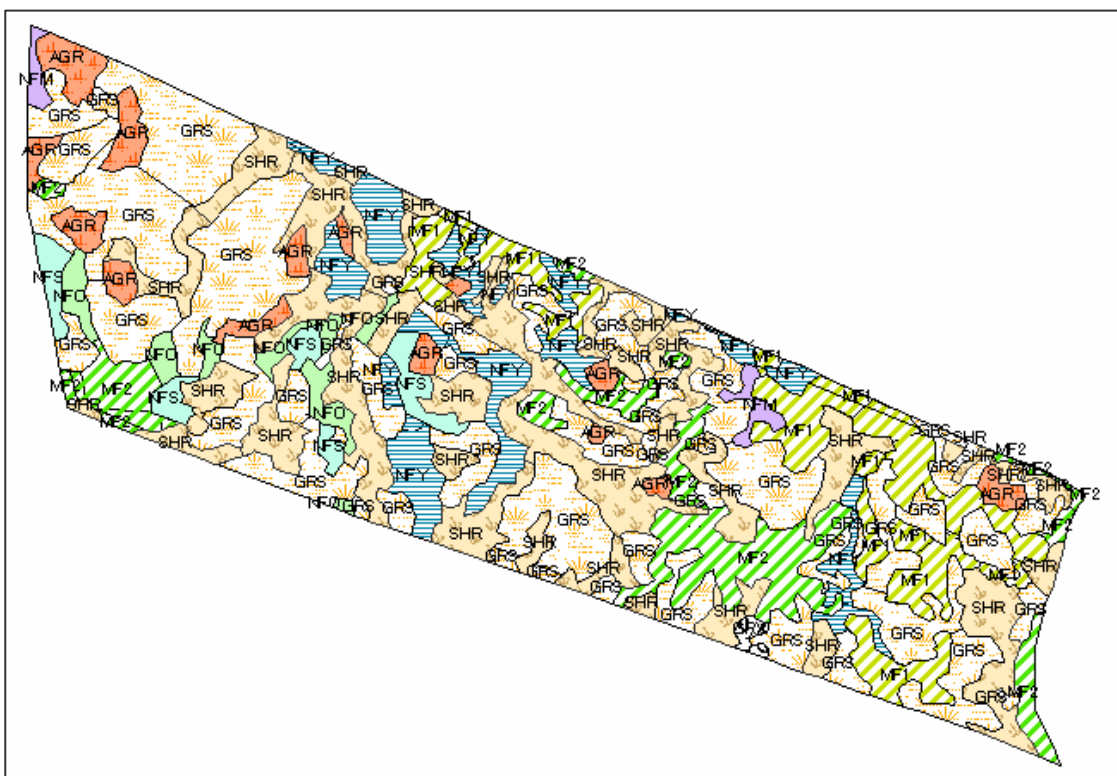
Follows is a example after filled the data.



Then give pattern and label for each forest/vegetation type. How to manage legend and label are explained later.



Give labels for every polygon.



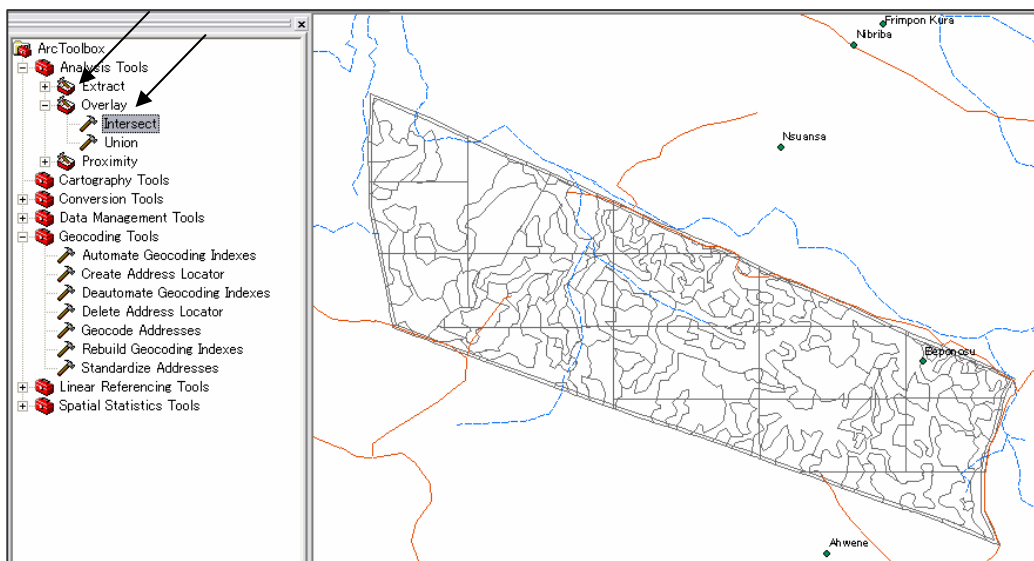
Vegetation map was completed.

4. The Vegetation map shall be divided into Forest Management Unit (compartment and sub compartment)

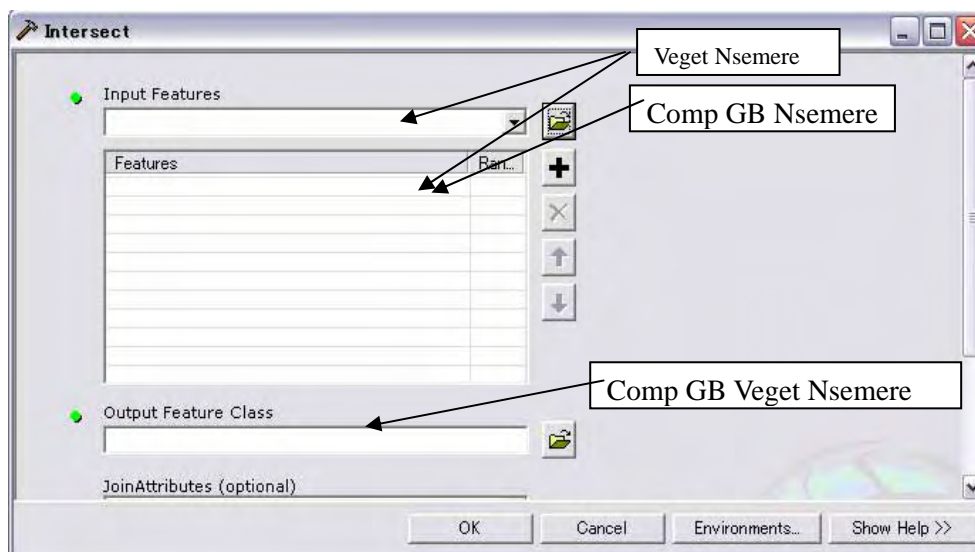
The vegetation map shows areas same vegetation category such as teak forest, grass land, etc. For the Forest management planning, the vegetation map and compartment system need to link. The forest management tasks generally organized based on the compartment system.. The forest area situation data stored Forest Inventory Book that recorded some number of has of Teak forest, grass lands, bush land , farm land, etc.

(1) Vegetation map and compartment map combining by Geo-processing (Intersect).

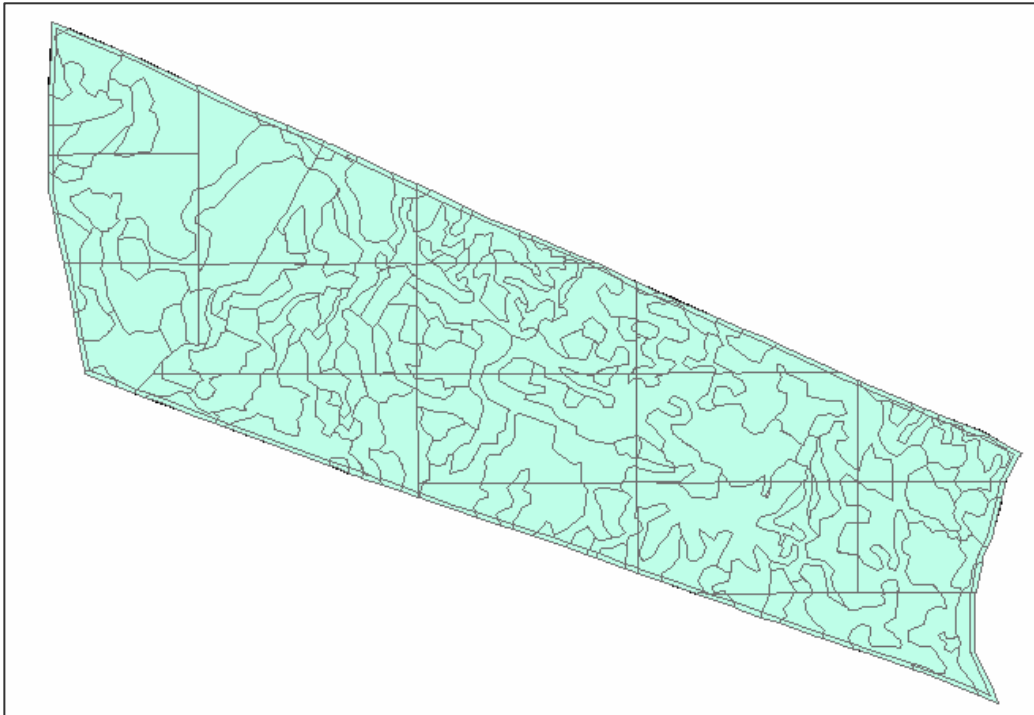
Call tool box  => Analysis tool => intersect => come a intersect tool window.



Give a file name to input column or select a layer within pull down list (“Veget Nsemere”) => the layer name automatically shift to feature column then input next layer in same manner (“Comp GB Nsemere”). => Give a name for new layer after intersected to be stored (Comp GB Veget Nsemere”) => OK

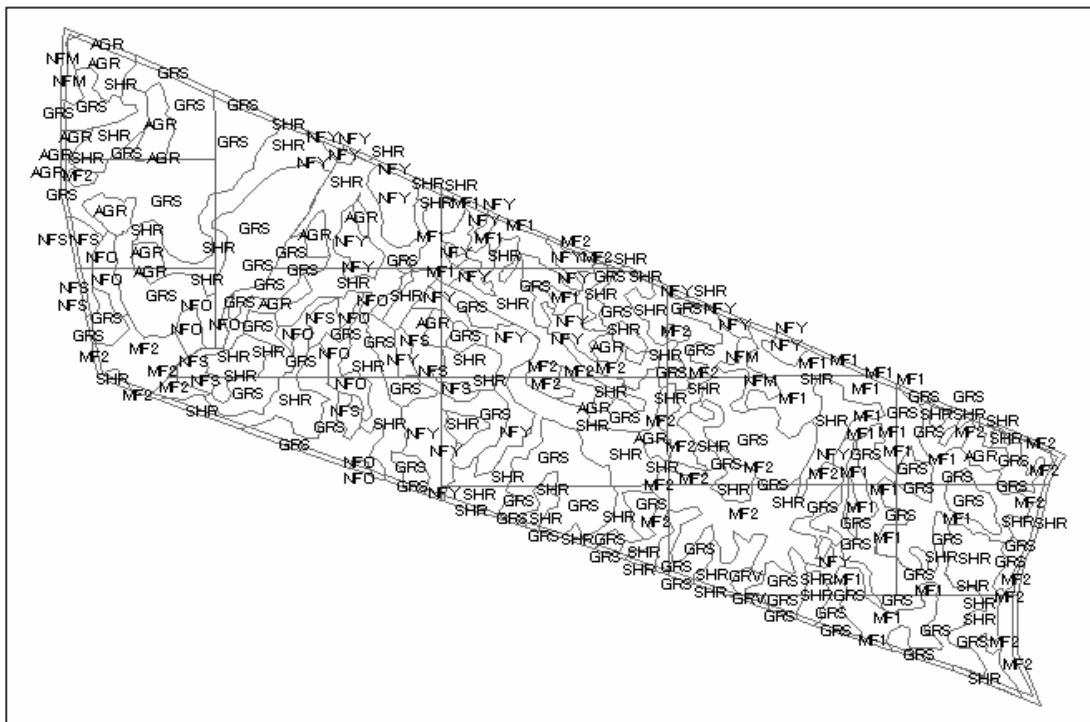


When “Intersect” had completed, Arc Map shows following layer (Comp GB Veget Nsemere).

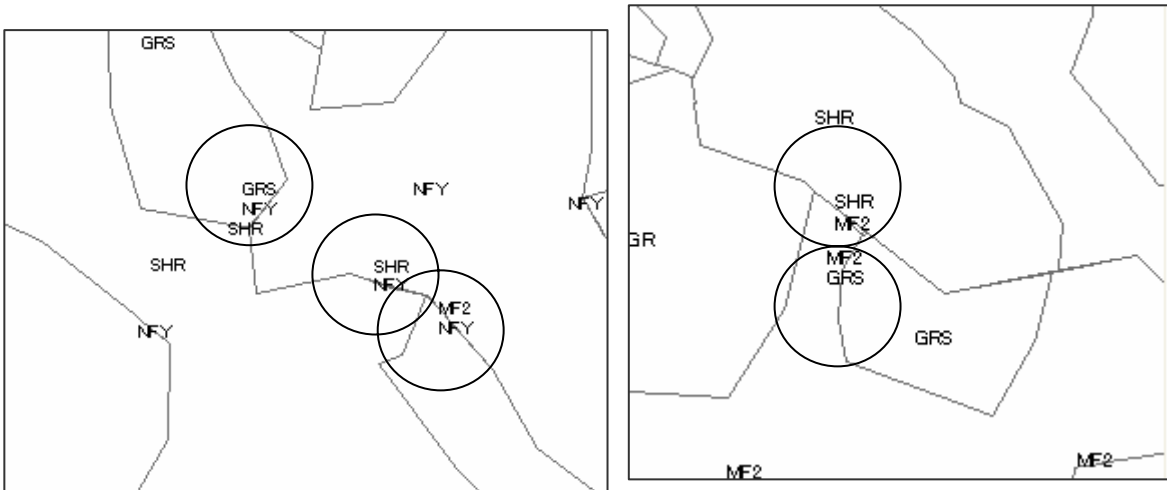


The Vegetation Map had been divided into compartment and Green belt areas& planting areas.

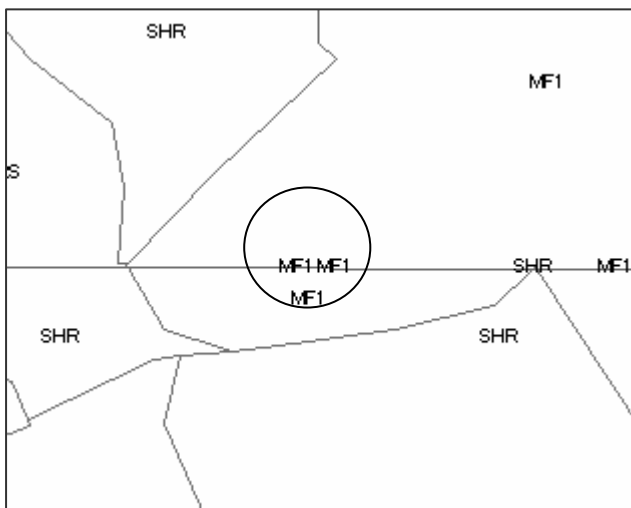
Next you may have to carry bag polygons elimination. Call attribute table, and calculate areas. Give labels for every polygon as Forest type, You found many area “0” columns/polygons, and many label letters along with visible polygons outline. You have to delete these bag polygons.



Zoom in the map, you can find following parts.



These was original vegetation polygons were duplicated.



This case was compartment polygons were duplicated.

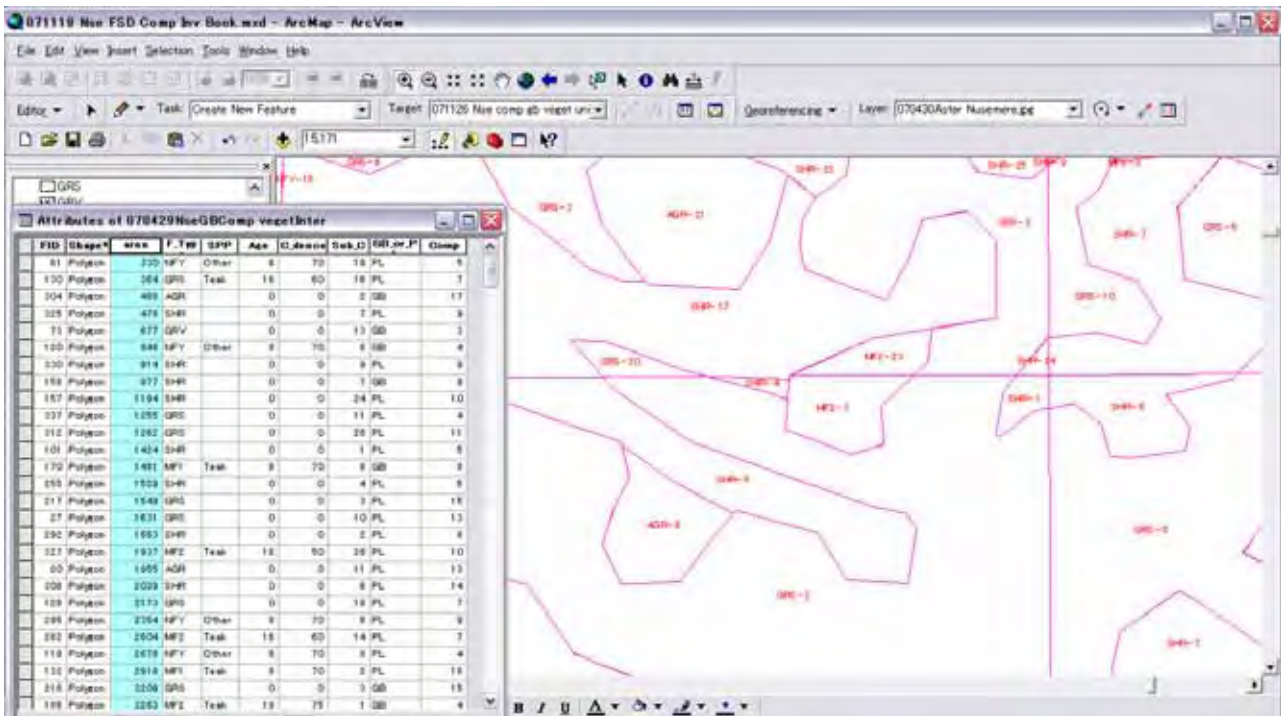
Attributes of 071126 Nse comp gb veget union

FID	Shape*	area	F_Type	SPP	Age	C_denc	Sub_G	GB_or_P
391	Polygon	0	MF1	Teak	8	65	0	PL
392	Polygon	0	MF1	Teak	8	70	0	PL
431	Polygon	0	SHR		0	0	0	PL
432	Polygon	0	NFY	Other	8	60	0	PL
355	Polygon	0	NFO	Other	65	10	0	PL
356	Polygon	0	NFO	Other	65	10	0	PL
433	Polygon	0	MF2	Teak	16	70	0	PL
434	Polygon	0	GRS		0	0	0	PL
347	Polygon	0	GRS		0	0	0	PL
348	Polygon	0	GRS		0	0	0	PL
415	Polygon	0	GRS		0	0	0	PL
416	Polygon	0	MF1	Teak	8	70	0	PL
94	Polygon	0	SHR		0	0	0	PL
387	Polygon	0	MF1	Teak	8	65	0	PL
388	Polygon	0	GRS		0	0	0	PL
385	Polygon	0	MF1	Teak	8	65	0	PL
386	Polygon	0	GRS		0	0	0	PL
353	Polygon	0	GRS		0	0	0	PL
354	Polygon	0	SHR		0	0	0	PL
395	Polygon	1	MF2	Teak	16	70	0	PL
396	Polygon	1	NFS	Other	65	15	0	PL
327	Polygon	1	AGR		0	0	0	PL
328	Polygon	1	SHR		0	0	0	PL
335	Polygon	1	SHR		0	0	0	PL
336	Polygon	1	NFY	Other	8	70	0	PL
417	Polygon	1	GRS		0	0	0	PL
418	Polygon	1	SHR		0	0	0	PL

Attribute table shows many polygons with area "0" existing

After removed all bag polygons, you start giving sub-compartment id on every polygon. The numbering order is start from upper rite corner and circle for opposite direction of crock moving direction (right to left, upper to down). Green belt part is given the same number just adjoined polygon id same forest type.

Then you will finish vegetation map showing compartment unit as bellow.

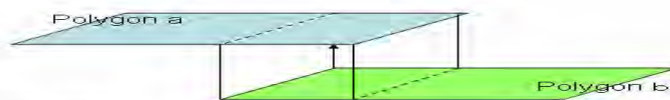


Small advice

When you try the bag polygons to merge to adjured polygon, you zoom in and find deprecated polygons generally 2. You have to merge small polygon "a" and b to "c". if polygon a is GRS and polygon "b" is SHR and "c" is grass, "d" is SHR, you want to merge the 2 small polygon as GRS c, you select a and c and merge, and then select a+c and b then merge. The 2 small polygons are removed and merged to polygon c. After merged, you need to check the forest type id if merged c shows SHR, you have to amend the attribute table as GRS. This occur the small polygons have deferent id of Forest type, GRS or SHR result is depend on which small polygon is upper or lower. You can not identify before you merged, therefore, some case shows GRS other case SHR.

The duplicated polygons are many, during this amendment, many polygons change the Codes, therefore, you make a copy file on different file name as vegetation original. Then you finish the amendment, call the saved original file and compare the 2 layer. If amended polygons shows deferent id with original, you have to amend the attribute table.

Original situation

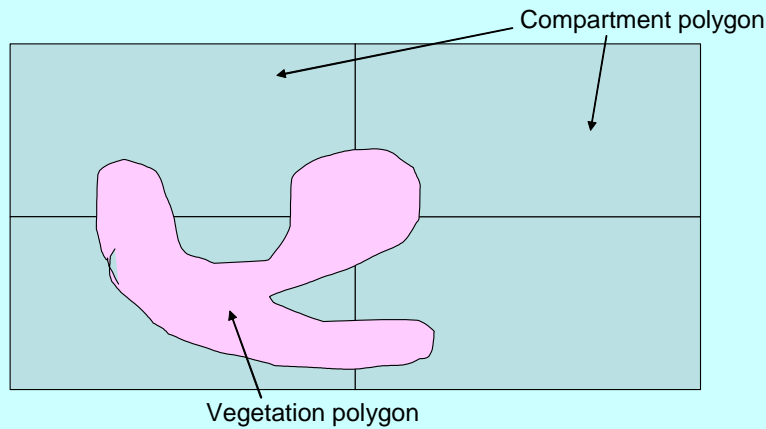


After intersect

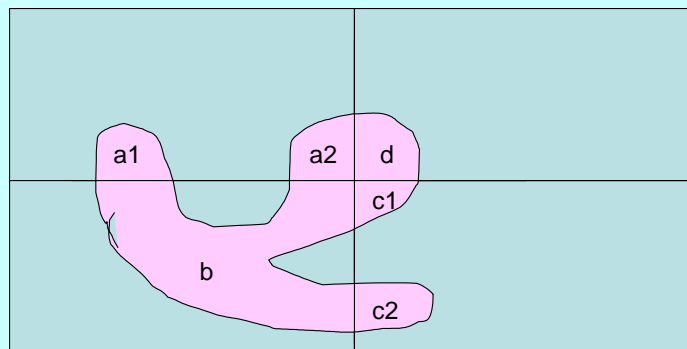


Small advice :

Amending polygons separated several positions after Intersect (Veget and Comp).

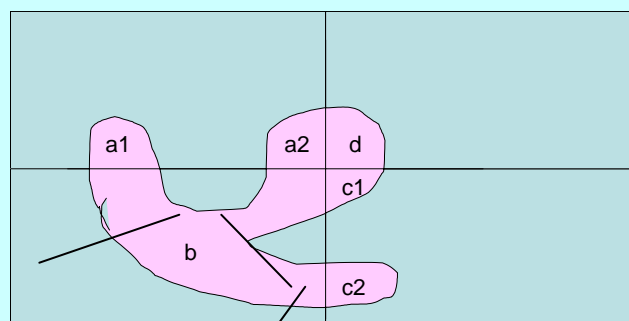


Some case a polygon divided into several compartments.



Computer divide 4 polygons a, b, c, and d for each block, then Arc map shows 6 parts 2 a1,a2, b, c1, c2 and d. Nevertheless, on attribute table 4 lines polygons only recorded. Arc map recognizing a1 and a2 is 1 polygon. You have to amend the polygon into 2 polygons. Measures for amending are explained on Section XX. But amending process is troublesome.

For avoiding these amendment, you divide the polygon covered more than 2 parts in a adjacent compartment in to several parts before Geoprocessing "Intersect" shall be done like below.



After the Intersect done, Arc map recognize 9 polygons, then after you can mage divided parts into a polygon within a same compartment.