



## Learning Unit: Student Guide

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- Title: Siting Ecoroofs – Planning Scenario

This project-based learning unit will introduce you to concepts of remote sensing and teach you how to use basic remote sensing analysis tools. You will learn how to take data from remote sensing software and import it into ArcMap for further analysis and display.

**The Scenario:** You are a member of a local sustainability committee that is interested in promoting Ecoroofs in the Eugene/Springfield Oregon Area. Ecoroofs are believed to reduce "urban island" heat, improve air quality by reducing temperatures and smog, and increase a building's insulation, which reduces energy consumption. Green roofs also create wildlife habitat and reduce storm-water runoff that can pollute streams. In addition, they can be used as a source for local food production. Your committee needs to identify suitable locations for Ecoroofs, and convince community members of the need for Ecoroofs. One strategy you plan to use is a map showing how much agricultural and unpaved land has been taken out of production as a result of urban growth. To do this you will need to use ENVI, a remote sensing software from ITT VIS, and ArcMap, a GIS software from ESRI.

### A WORD ABOUT THE FORMAT.

The step-by-step process in this lesson is designed to teach you basic tools of ENVI. You will use the ENVI software to analyze a Landsat image.

- Steps within a topic are indicated with an arrow
  - Arrows indicate menus that expand – For example To Save click File → Save [or click file then click save]
- Words in “ ” Indicate the Menu word to look for – For example click on “File” → “Save As” → navigate to a folder.
- Sequential numbers are used to indicate questions that requires a response.
- A blue arrow is used to indicate a new step.

## Part 1 – Siting Ecoroofs: Concepts of Remote Sensing

In part one of this activities student teams will explore two Landsat images – one of the Eugene and Springfield, Oregon urban area in 2008 and one of the same area in 1984. You will determine the percent of land cover for your team’s time period. Then will compare the two time periods to evaluate urban growth over time. Finally, you will compare and discuss the two methods used to assign land cover values. .

### A) PIXEL VALUE ASSIGNMENT

1. Take one of the Landsat color images and the clear acetate that has a grid overlay. Paper clip them together making sure the cross hairs + line up.

Two Landsat images are used in this activity – one from July 1984 and the other from July 2008. Each pair of students will be give one of the two images.

2. Using the method indicated on your acetate, color each grid square according to the land cover represented in each grid square. Use a diagonal slash pattern to fill in the square.



Some students will use the center point method and some will use the plurality method.

1. The central point method: Look at the center of each grid. Determine what land cover type is in the center. The entire square will be colored to represent that land cover type.
2. Plurality method: Evaluate each grid and determine which land cover type is most represents. Then color the square to represent that land cover.

Color: urban areas – yellow, water – blue; forest – orange, agricultural and other vegetation – green). Every grid cell will be assigned a color.

### B) PERCENT LAND COVER.

- 1.1. Calculate the percentage for each land cover type.

Total number of grids = \_\_\_\_\_

Percent of urban grids = \_\_\_\_\_ (urban grids/total grids) \* 100

Percent of water grids = \_\_\_\_\_ (water grids/total grids) \* 100

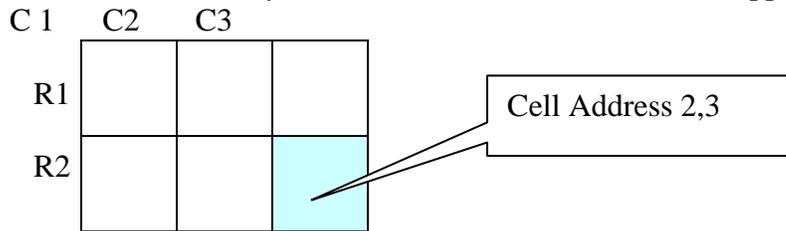
Percent of forest grids = \_\_\_\_\_ (forest grids/total grids) \* 100

Percent of agricultural grids = \_\_\_\_\_ (agriculture grids/total grids) \* 100

### C) LAND COVER CHANGE

- ▶ Find some one who has created a raster grid representing the other year and compare results. You will do this by overlaying the two acetate grids (your grid and their grid).
- ▶ Record the cell location of grids representing the 2008 image that are different from grids representing the 1984 image.

Raster cells are addressed by row and column numbers with the upper left corner being R1 and C1



#### D. RASTER TO VECTOR

- ▶ . Place a clear (non-grid) acetate over your colored acetate.
- ▶ Combine all the grids that are the same land cover type and are next to each other into one polygon and color the polygons with the corresponding land cover color.



#### E) PIXEL ASSIGNMENT EVALUATION

- ▶ . Find someone who used the opposite method to assign pixel values

**1.2.** How different are the classifications made by the two methods?

- ▶ Compare the percent breakdown.

**1.3** Which method is more accurate? Why would you use one over the other?

#### F) REFLECTION

**1.4.** Write a brief paragraph explaining how the value of a pixel is a generalized representation of actual land cover. What assumptions have to be made? What were some problems you encountered?

## Part 2 – Siting Ecoroofs: Introduction to ENVI ( 1 hour)

In this activity you will learn how to open a Landsat file. You will explore the various bands in a Landsat image using remote sensing software - ENVI. ENVI is designed to process and analyze satellite imagery. In Part Two you will explore the navigation tools, learn how to load a RGB image, and selected regions of interest.

### A) OPEN ENVI SOFTWARE

- ▶ . Double click the ENVI 4.5 Icon



A Main Menu toolbar bar will open



### B) LOAD A LANDSAT IMAGE

- ▶ Click “File” → “Open External File” → “Landsat” → “GeoTiff”
- ▶ Navigate to the geotiff2008 folder with the Landsat GeoTiffs → Select all the Tiff files to add all the layers → Choose “Open”

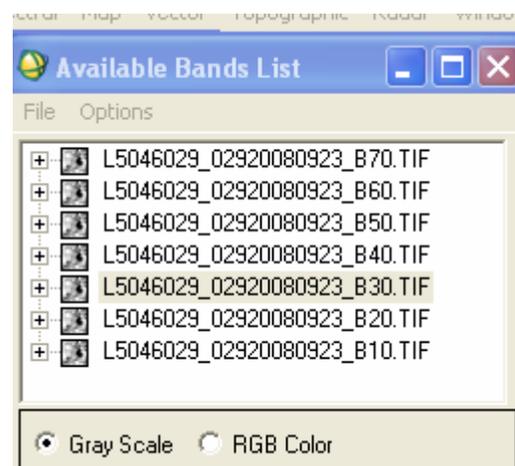


After the layers are loaded, a window showing the available spectral bands opens.

- ▶ Click the + to expanded to each band
- ▶ Click the “Map Info” + sign

2.1. What is listed in the Map Info?

2.2. List each band and its pixel size.



C) DISPLAY VARIOUS BANDS

- ▶ . Expand B70.TIF → Click on Band 1  
→ Make sure the “Gray Scale” radio button is selected



The TIF will show in the “Selected Band” window

- ▶ Click the “Load Band” Button



Three windows show on your screen: a large view window and two small windows - one to scroll and one to zoom. The three windows work together. As you pan over each of the windows your mouse pointer becomes a cross hair.

- ▶ Click somewhere in the #1 Scroll window- The other two windows will load. Practice moving around in each window.
- ▶ Click the “RGB Color” radio button in the “Available Bands”: window. A new menu opens.
- ▶ Make sure the “R” radio button is selected → Expand the B30.Tif and select Band 1. It will be loaded in the R selection. The B30 refers to the spectral layer from the Landsat image.
- ▶ Add the B20.Tif to the G → add the B10.Tif to the B. → Click “Load RGB”

You are looking at the Landsat image in a 3,2,1 color combination which is considered “True Color.”

**2.3.** Using the 3, 2, 1 (RGB) combination, in general, what color is the dense forest land on either side of the Willamette Valley? What color is the urban landscape? What color is water?

- ▶ Fill in the chart below to evaluate the different RGB and band combinations. Choose a combination of your own for the last two rows.

<b>R (red)</b>	<b>G (green)</b>	<b>B (blue)</b>	<b>Forest</b>	<b>Agriculture</b>	<b>Urban</b>	<b>Water</b>
3	4	5				
4	3	2				
7	4	2				
5	4	3				
1	4	7				

## **Landsat Thematic Mapper (TM) spectral band definitions**

**Band 1: 0.45-0.52** micrometres (blue-green) - provides increased penetration of water bodies and also capable of differentiating soil and rock surfaces from vegetation and for detecting cultural features.

**Band 2: 0.52-0.60** micrometres (green) - it is sensitive to water turbidity differences; it highlighted the turbid water in the Barkley Lake. Because it covers the green reflectance peak from leaf surfaces, it has separated vegetation (forest, croplands with standing crops) from soil. In this band barren lands urban areas and roads and highways have appeared as brighter (lighter) tone, but forest, vegetation, bare croplands, croplands with standing crops have appeared as dark (black) tone. Also the Kentucky Lake has appeared as black tone.

**Band 3: 0.63-0.69** micrometers (red) - senses in a strong chlorophyll absorption region and strong reflectance region for most soils. It has discriminated vegetation and soil. But it couldn't separated water and forest. Forest land and water both have appeared as dark tone. This band has highlighted barren lands, urban areas, street pattern in the urban area and highways. It has also separated croplands with standing crops from bare croplands with stubble.

**Band 4: 0.76-0.90** micrometers (near infrared) operates in the best spectral region to distinguish vegetation varieties and conditions. Because water is a strong absorber of near IR, this band has delineated water bodies (lakes and sinkholes), distinguished between dry and moist soils (barren land and croplands). In this band croplands and grasslands have showed higher reflectance (brighter tone) than the forest. This band has also separated croplands from bare croplands. Since standing crops (vegetation) has higher reflectance in the near IR region, they have appeared as brighter tone and due to presence of moisture content in the bare croplands, they have appeared as darker tone. In the band 4 barren lands, urban areas and highways have not been highlighted and they appeared as dark tone. Band 4 is useful for crop identification and emphasizes soil-crop and land-water contrast.

**Band 5: 1.55-1.75** micrometers (near infrared) - is sensitive to the turgidity or amount of water in plants. Band 5 has separated forest lands, croplands, water body distinctly. Forests have appeared as comparatively darker tone than the croplands (light gray). Band 5 has separated water body (dark tone) from barren lands, croplands, and grass lands (lighter tone). Since urban area and croplands have responded almost in same spectral reflectance band 5 could not be able to separate these areas.

**Band 7: 2.08-2.35** micrometers (shortwave infrared) - has separated land and water sharply. Band 7 has strong water absorption region and strong reflectance region for soil and rock. Urban area, croplands, highways, bare croplands have appeared as bright tone and water body, forest have appeared as dark tone.

Band 6: 10.4-12.5 micrometers (thermal infrared)

<b>Terrain Feature</b>	<b>Reflectance Response</b>
<b>Water Bodies</b>	Generally reflect high in the visible spectrum, however, clearer water has less reflectance than turbid water. In the Near IR and Mid-IR regions water increasingly absorbs the light making it darker. This is dependent upon water depth and wavelength. Increasing amounts of dissolved inorganic materials in water bodies tend to shift the peak of visible reflectance toward the red region from the green region (clearer water) of the spectrum.
<b>Soil</b>	Northern latitudes have black soils and tropical regions have red soils. Soil reflectance decreases as organic matter increases. As soil moisture increases, reflectance of soil decreases at all wavelengths. Texture of soil will cause increased reflectance with decreased particle size, i.e., the bigger particles (rocks, sand, and soils) basically cast a larger shadow.
<b>Vegetation</b>	The spectral reflectance is based on the chlorophyll and water absorption in the leaf. Needles have a darker response than leaves. There will be various shades of vegetation based on type, leaf structure, moisture content and health of the plant.
<b>Man-Made Materials</b>	Concrete and asphalt both display spectral curves that generally increase from the visible through the Near IR and Mid-IR regions. However, as concrete ages, it becomes darker and as asphalt ages it becomes lighter.
<b>Snow and Ice</b>	Old snow may develop a compacted crust and the moisture content increases which make it less reflective in the Near IR and Mid-IR region. It is possible to compare old and new snow by its Mid-IR reflectance.

<b>R, G, B</b>	<b>Potential Information Content</b>
<b>4,3,2</b>	The standard "false color" composite. Vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. Coniferous trees will appear darker red than hardwoods. This is a very popular band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Generally, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. This TM band combination gives results similar to traditional color infrared aerial photography.
<b>3,2,1</b>	The "natural color" band combination. Because the visible bands are used in this combination, ground features appear in colors similar to their appearance to the human visual system, healthy vegetation is green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray, and shorelines are white. This band combination provides the most water penetration and superior sediment and bathymetric information. It is also used for urban studies. Cleared and sparsely vegetated areas are not as easily detected here as in the 4 5 1 or 4 3 2 combination. Clouds and snow appear white and are difficult to distinguish. Also note that vegetation types are not as easily distinguished as the 4 5 1 combination. The 3 2 1 combination does not distinguish shallow water from soil as well as the 7 5 3 combination does.
<b>7,4,2</b>	This combination provides a "natural-like" rendition, while also penetrating atmospheric particles and smoke. Healthy vegetation will be a bright green and can saturate in seasons of heavy growth, grasslands will appear green, pink areas represent barren soil, oranges and browns represent sparsely vegetated areas. Dry vegetation will be orange and water will be blue. Sands, soils and minerals are highlighted in a multitude of colors. This band combination provides striking imagery for desert regions. It is useful for geological, agricultural and wetland studies. If there were any fires in this image they would appear red. This combination is used in the fire management applications for post-fire analysis of burned and non burned forested areas. Urban areas appear in varying shades of magenta. Grasslands appear as light green. The light-green spots inside the city indicate grassy land

	cover - parks, cemeteries, golf courses. Olive-green to bright-green hues normally indicate forested areas with coniferous forest being darker green than deciduous.
<b>4,5,1</b>	Healthy vegetation appears in shades of reds, browns, oranges and yellows. Soils may be in greens and browns, urban features are white, cyan and gray, bright blue areas represent recently clearcut areas and reddish areas show new vegetation growth, probably sparse grasslands. Clear, deep water will be very dark in this combination, if the water is shallow or contains sediments it would appear as shades of lighter blue. For vegetation studies, the addition of the Mid-IR band increases sensitivity of detecting various stages of plant growth or stress; however care must be taken in interpretation if acquisition closely follows precipitation. Use of TM 4 and TM 5 shows high reflectance in healthy vegetated areas. It is helpful to compare flooded areas and red vegetated areas with the corresponding colors in the 3 2 1 combination to assure correct interpretation. This is not a good band combination for studying cultural features such as roads and runways.
<b>4,5,3</b>	This combination of near-IR (Band 4), mid-IR (Band 5) and red (Band 3) offers added definition of land-water boundaries and highlights subtle details not readily apparent in the visible bands alone. Inland lakes and streams can be located with greater precision when more infrared bands are used. With this band combination, vegetation type and condition show as variations of hues (browns, greens and oranges), as well as in tone. The 4,5,3 combination demonstrates moisture differences and is useful for analysis of soil and vegetation conditions. Generally, the wetter the soil, the darker it appears, because of the infrared absorption capabilities of water.
<b>7,5,3</b>	This band combination also provides a "natural-like" rendition while also penetrating atmospheric particles, smoke and haze. Vegetation appears in shades of dark and light green during the growing season, urban features are white, gray, cyan or purple, sands, soils and minerals appear in a variety of colors. The almost complete absorption of Mid-IR bands in water, ice and snow provides well defined coast lines and highlighted sources of water within the image. Snow and ice appear as dark blue, water is black or dark blue. Hot surfaces such as forest fires and volcano calderas saturate the Mid-IR bands and appear in shades of red or yellow. One particular application for this combination is monitoring forest fires. During seasons of little vegetation growth the 7 4 2 combination should be substituted. Flooded areas should look very dark blue or black, compared with the 3 2 1 combination in which shallow flooded regions appear gray and are difficult to distinguish.
<b>5,4,3</b>	Like the 4 5 1 combination, this combination provides the user with a great amount of information and color contrast. Healthy vegetation is bright green and soils are mauve. While the 7 4 2 combination includes TM 7, which has the geological information, the 5 4 3 combination uses TM 5 which has the most agricultural information. This combination is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation.
<b>5,4,1</b>	This will look similar to the 7 4 2 combination in that healthy vegetation will be bright green, except the 5 4 1 combination is better for agricultural studies.
<b>7,5,4</b>	This combination involves no visible bands. It provides the best atmospheric penetration. Coast lines and shores are well defined. It may be used to find textural and moisture characteristics of soils. Vegetation appears blue. If the user prefers green vegetation, a 7 4 5 combination should be substituted. This band combination can be useful for geological studies.
<b>5,3,1</b>	This combination display topographic textures while 7 3 1 may display differences in rock types.

Land Cover Type	Spectral Band Combination
Water	Band 1, 4 & 7 / Band 1, 2 & 3
Urban	Band 1,4 & 7
Farmland	Band 1, 2 & 3
Forest	Band 1, 4 & 7
Salt Scald	Band 1, 2 & 3
Remnant Vegetation	Band 1, 4 & 7
Irrigated Vegetation	Band 1, 4 & 7

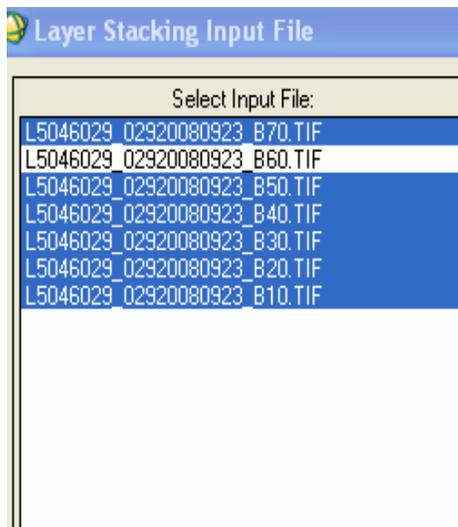
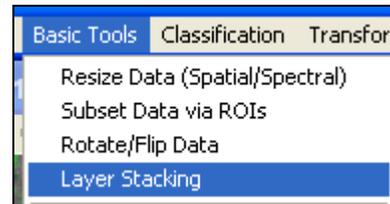
D. Evaluation – 2.4. Which combination do you think differentiates the urban or built landscape best? Which shows water more clearly?

### Part 3: Ecoroofs – Create a Data Cube and Create a Sub-Set by Coordinates (1 hr)

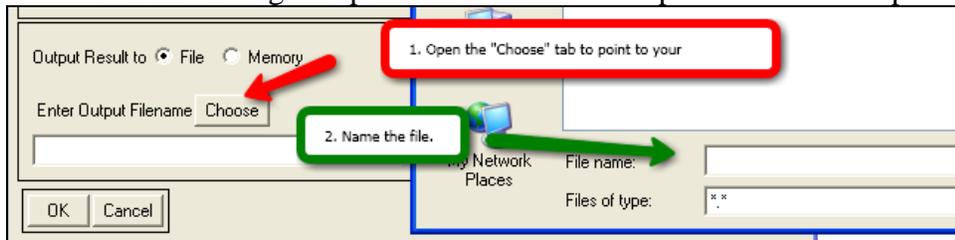
In part three of the activity you will process the Landsat image to use only the bands you need for analysis and then create a smaller sub-set area.

#### A) LOAD THE GEOTIFF

- ▶ . Open the Geotiff you have been assigned to analyze
- ▶ . Go to “Basic Tools” in the main ENVI menu → “Layer Stacking” → “Import file”
- ▶ . Select bands 1 through 5 and band 7 → OK



- ▶ . Leave the “Output Map Projection” to UTM. This is the geographic coordinate system you will be using in ArcMap.
- ▶ . Click “Reorder Files” → Click the B70.Tif and drag it to the bottom of the stack → Reorder the stack in numerical order → OK
- ▶ . Click “Choose” to “Enter Output File” name and locate your workspace → name the file something to represent the data and the process. For example: ES2008stack1



The new data cube will be loaded in your “Available Bands List.”

The cube and stacking process creates two new files - A “file” and a “HDR” file. The HDR is the file you will evaluate.

If you stop your ENVI session and restart at a later time, you will Click “File → Open Image File → Navigate to your data cube → Select the HDR file.



### 3.1 Why are you excluding the band 60.Tif?

#### B) CREATE A SUBSET

The Landsat image you are currently using is much larger than the area you want to evaluate. You are going to crop the data cube by creating a subset using specific geographic coordinates.

- ▶ Click “Basic Tools” → “Resize Data (Spatial/Spectral)” → Select your Data Cube → “Spatial Subset” → “Map”
- ▶ Set the upper and low decimal degree parameters using the coordinates below. Make sure the coordinates are set to UTM

Upper left -		Lower right	
481017.31	E,	509089.812	E
4897740.31	N	4866792.04	N

- ▶ . Once you have set the coordinates, OK each of the three windows.

Set the name and location of the subset. i.e. ES2008ss1

The subset should be loaded in your Available Bands window automatically.

### C) LOAD THE SUBSET

- ▶ Click “File” → “External File” → “Landsat” → “HDF” → Navigate to your folder → Select the name of your subset. Load the HDR subset file into each of the RGB Color bands

### D. EVALUATION:

3. 2. In the display window, double click to open the “Cursor Location/Value window”. Place the cursor in the northwest corner and record the latitude and longitude of that corner. Now place it in the southeast corner and record the latitude and longitude.

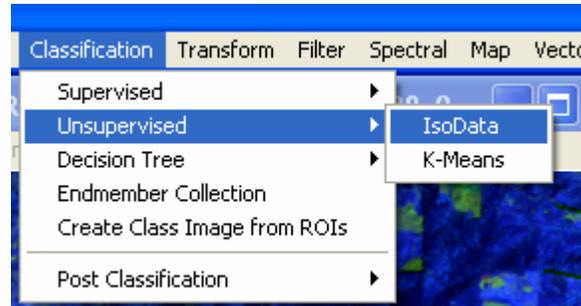
## Part 4 – Siting Ecoroofs: Data Classification and Comparison (6 hours)

Now that you have created a data cube and a subset you are ready to consolidate the various pixel values into two land cover categories – urban/built and non urban

There are two types of classification you can run in ENVI - supervised and unsupervised. A supervised classification is done by identifying known areas on the image and setting them to specified classes. An unsupervised classification relies on statistical groups of similar pixels. Once the unsupervised classification is run, the pixel values are compared to known pixel attributes in the image.

### A ) UNSUPERVISED CLASSIFICATION

- ▶ Load your subset data → in the main menu Click Classification → Choose Unsupervised → IsoData



- ▶ In the classification Input File window – Choose the subset you created → OK
- ▶ . Set “Number of Classes” Min = 7 and Max = 15 → Set “Iterations” to 5 → Set the “File Output Name” es2008class1 → OK

This will take a few minutes to run.

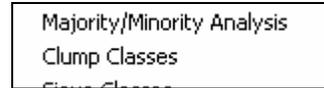
- ▶ Load the classified subset to a New Display Window → “RGB Color.”
- ▶ Click the classified file and set it in each of the RGB bands. You will set the same file in each band.
- ▶ Link the subset and the classified image Click the display windows – “Tool” → “Link” → Link Displays



B) COMBINE (CLUMP) CELLS IN THE CLASSIFIED IMAGE.

Clumping will combine all the pixels that are the same value and next to each other into continuous areas. This is like the paper and pencil exercise you did in part one. Clumping is another way to generalize data.

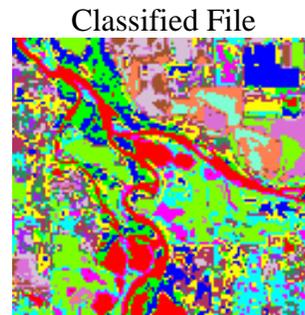
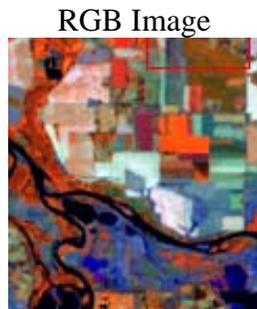
. In the main menu choose the “Classification” → “Post Classification” → “Clump Classes”



- ▶ Choose the unsupervised classification → “OK” → “Select All Items” → Enter Output File Name”es2008clump1 → OK
- ▶ Load the clumped image into a new display using RGB.
- ▶ Link the clumped and the subset image. Click the display window “Tool” → “Link “ → Link Displays.
- ▶ Right click and open the “Cursor Location /Value” window.

You set 15 possible classifications. Explore the class value for the various pixels

- ▶ Toggle back and forth between the image and the classification to see what each class values represents.



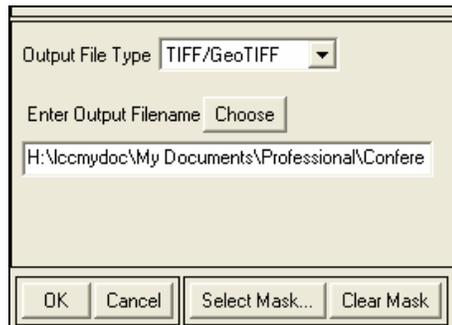
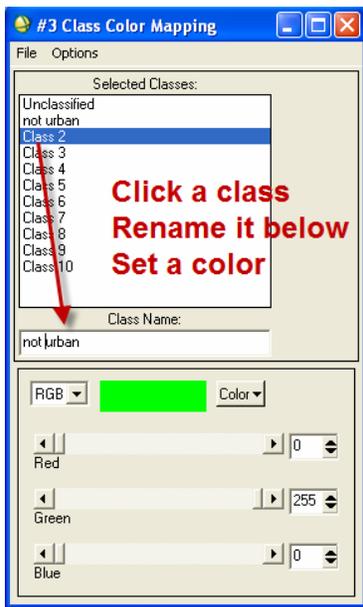
**4.1. Fill in the Chart.**

Class Value	Land Cover Represented	Reclassify (0 = non urban) (1= urban)
Unclassified		
1		
2		
3		

4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

**C) ASSIGN COLOR CLASSES THAT REPRESENT URBAN OR NON URBAN LANDCOVER.**

- ▶ In the display window of your clumped image choose “Tools” → “Color Mapping” → “Class Color Mapping”
- ▶ Reassign class values to urban or not urban and assign only two colors.



- ▶ . Close → Save changes
- ▶ You will need to go through this process several times until it seems correct. Experiment with changing the number of classes to see if you can get a more accurate image.

**D) EXPORT TO AN ARCMAP GRID FILE**

- ▶ When you have the best fit create a GRID file. Choose File from the main menu → File → Save AS → ESRI Grid – Name the file. Remember not more than 13 characters.
- ▶ Open the GRID in ArcMAP
- ▶ Add the Eugene/Springfield shapefiles in the geotiff2008 folder.
- ▶ Add the 1984 Grid that has been created for you.

E) EVALUATION

4.2. How closely does the processed Landsat image align with the shapefiles? Can you detect any land cover changes at this stage of the evaluation?

Part Five: ArcGIS, ArcView, ArcMap

The rests of the project will be done in ArcMap.

- You will re-assign values to the GRIDS, setting them to urban and non urban.
- Then you will compare the two years to see if you can use this as one of your documents supporting the need for Ecoroofs in the Willamette Valley.
- In ArcMap you will identify and digitize suitable rooftops based on their area.
- Then you will calculate the total area available for the Ecoroof project in the Eugene and Springfield area
- You will calculate the estimated cost to Green Up the area

A) OPEN ARCMAP

- ▶ Add the two Grid Files (eugsp2008 and eugsp1984)

5.1. What is the 1984 pixel size?

5.2. What is the 2008 pixel size?

5.3. Do the two GRIDS line up?

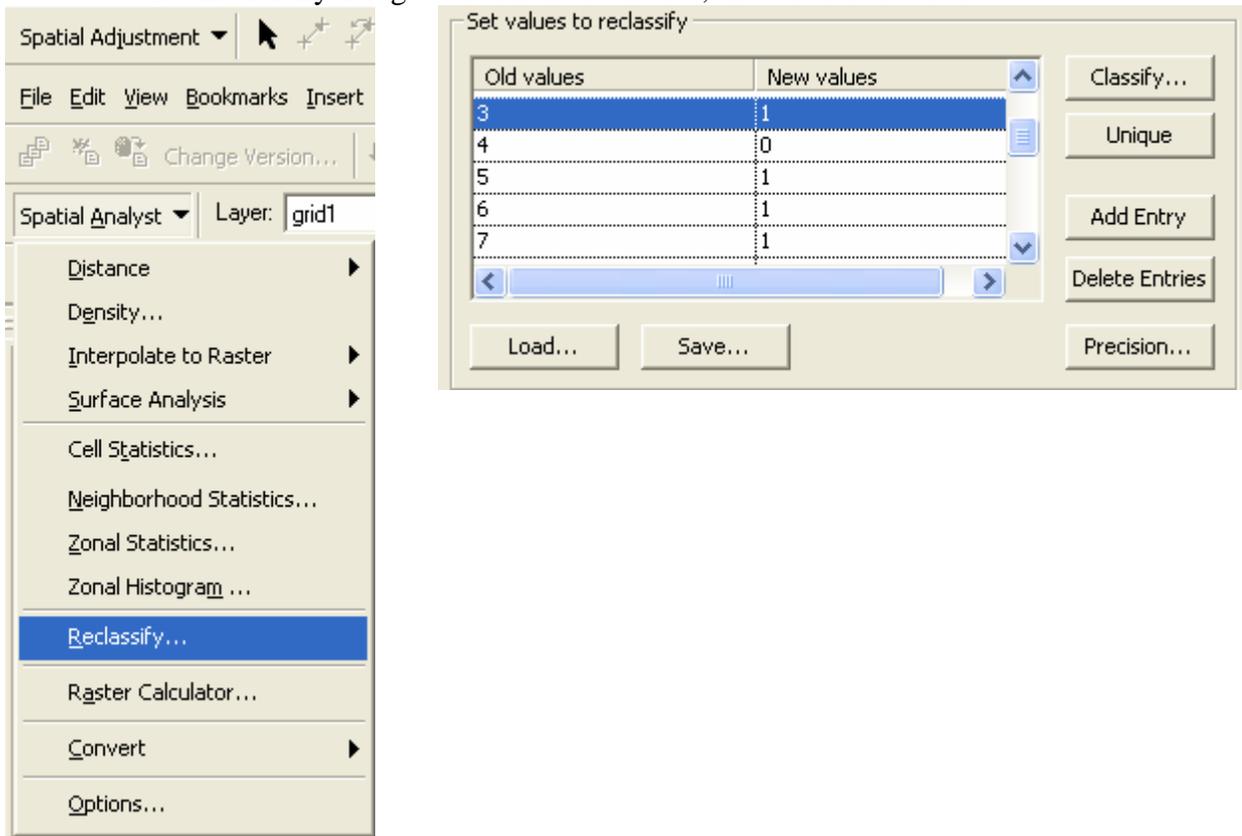
5.4. Identify which cells were urban in the 2008 Analysis - The data for 1984 is done look at the source properties for each data set.

1984	1984	1984	2008	2008	2008
Data	Land Cover	Re class	Class	Land Cover	Re class
1	Forest				
2	Forest				
3	Forest				
4	Urban				
5	Urban				
6	Urban				
7	Soil				
8	Forest				
9	Soil				
10	Ag field				
11	Ag field				
12	Urban				
13	Soil				
14	Wetland				
15	Urban				
16	Did not use	Na			
17	Did not use	Na			
18	Did not use	Na			
19	Did not use	Na			
20	Did not use	Na			

B) RECLASSIFY THE GRID FILES

- ▶ Load the Spatial Analyst Extension → Choose “Reclassify”
- ▶ Select one of the GRID Files in the Input raster → Choose the Value field → Set an Output grid.

- ▶ Reclassify using “0” for non urban area, and “1” for urban areas.



- ▶ Add the 1984 reclassified grid. It has been reclassified already.

5.6. How many cells are in the 1 class in 1984?

5.7. How many cells are in the 0 class in 1984?

5.8. What percentage is urban in 1984?

5.9. What area is the area in meter and feet for the 1984 Urban land cover?

- ▶ Follow the same procedure to reclassify and calculate the urban land cover for 2008.

5.10. How many cells are in the 1 class in 2008?

5.11. How many cells are in the 2 class in 2008?

**5.12.** What percentage is urban in 2008?

**5.13.** Write a paragraph describing the changes you see in urban area over the study time period. What area is the area in meter and feet for the urban land cover for each year?

**Part 6: Digitize rooftops and calculate area – Do not go further.**

- ▶ Load the 2008 Tiff images of the Eugene and Springfield area.
- ▶ Create a file geodatabase and set up a feature class called ecoroof. Set the projection to UTM WGS-1984 Zone 10 N.
- ▶ When you have finished digitizing the rooftops, create a subset using an attribute query for all roofs with an area larger than 6,000 square feet.
- ▶ Use the Field  $\Sigma$  tool to get the summary of square meters. Convert this to square feet.
- ▶ Convert the square footage to acres.
- ▶ Choose five building that you can field check for suitability based on slope.

# Grants Could Give City ‘Ecoroof’ Plan a Boost

The Portland Tribune, Sep 16, 2008

Portland’s Bureau of Environmental Services will offer grants as incentives to install new ecoroofs – those vegetated roof systems that reduce storm water runoff, improve air quality and save energy – around the city.

The ecoroof grant program is part of Portland’s Grey to Green effort to accelerate the city’s work to increase the city’s storm water management system, protect sensitive natural areas and improve habitat.

Portland’s City Council will vote Wednesday to start the grant program.

“Portland is already a leader in green storm water technology,” said City Commissioner Sam Adams. “We hope this incentive program will result in many more ecoroof projects and more innovative approaches to replacing traditional roofs.”

The Grey to Green goal is to add 43 acres of new ecoroofs in five years. The city has about nine acres of ecoroofs on more than 90 buildings. The incentive grants will pay up to \$5 per square foot for new ecoroof projects, which typically cost between \$5 and \$20 per square foot.

The city will spend about \$300,000 on grants in this year, and will make grant funds available during the next five years. Industrial, residential, commercial and mixed-use projects are eligible for the incentive program.

The city begins accepting grant applications on Oct. 28. An Environmental Services committee will review applications quarterly and award grants.

Given the estimated cost of the Grey to Green roof project in Portland., Oregon, what would it cost to add your estimated square footage of Ecoroof.?

## Part 7 – Put it together in a Presentation.

- Take the information you have created and in teams of four (one for each sector of the city) create a short PowerPoint or poster presentation.
  - You must have a map showing the UGB
  - The proposed Ecoroofs
  - A graph or map showing the urban growth
  - Data showing the area to be converted and the cost of the conversions.