10. Interpretation of Digital Image Data

- Some Definitions

- **Photo Interpretation:** Examining the aerial photographs/images for the purpose of identifying objects and judging their significance
- **Photography:** Process of producing images on a sensitized surface by the action of light or other radiant energy
- **Image:** Optical counterpart of an object produced by a lens or mirror or other optical system
- **Photogrammetry:** Science of obtaining reliable measurements by means of photography

Airphoto/Image Interpretation Activities

- **Detection and Identification** of objects, features, phenomena and processes. Based on his response, interpreter puts labels reflecting some qualitative terms as. likely, possible, probable or certain ..etc

- **Measurement:** Taking quantitative measurement, however techniques used by interpreters are not as precise as the measurements taken by photogrammetrists using sophisticated instrumentation

- **Problem Solving:**

  - Identifying objects from a study of associated objects

  - Identifying object complexes from an analysis of their component objects

  - Finding out the effect of some process and suggesting a probable cause.

  - Answer may be expressed as a number of likely scenarios with certain probabilities of correctness

Elements of Image Interpretation

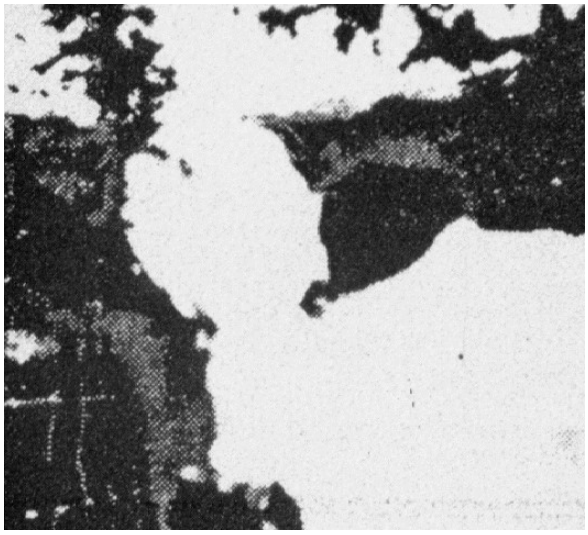
1. First Order (Basic) Elements of Image Interpretation

i) Tone/Color:

Tone: Each distinguishable variation from white to black

Examples of tone are shown below:





Color: Each distinguishable variation on an image produced by a multitude of combinations of hue (kind, variety), brightness value and chroma

Example of color is shown below:



ii) **Resolution:** Is the ability of the entire photographic system (including lens, exposure, processing and other factors) to yield a sharply defined image.

In interpretation, resolution is usually given in terms of ground resolved distance which is the smallest contrast object that can be detected and identified on a photo

2.1. Second order (Geometric Arrangements of Objects) Elements of Image Interpretation

i) Size:

- Used in discrimination of objects and features (e.g. cars vs. trucks or buses; bush (çalılık) versus trees, etc.)

- Used as a diagnostic characteristic in which both the relative and absolute sizes of objects are important

- Also used in judging the significance of objects and features (e.g. size of agricultural fields related to water use in arid (kurak) areas; size of runways gives an indication of the types of aircraft that can be accomodated)

ii) Shape of objects/features provide diagnostic clues that aid identification

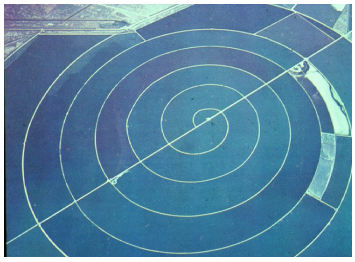
- Man-made features have straight edges, however natural features do not

- Roads can have right angle turns, railroads do not.

Examples of shape are given below:







2.2. Second order (Spatial Arrangement of Tone/Color) Elements of Image Interpretation

i) Texture: Frequency of change and arrangement of tones.

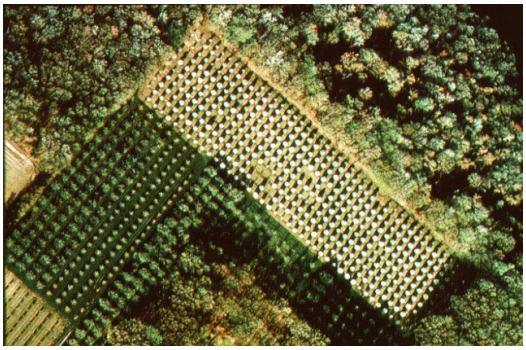
- Texture is a micro image characteristic

- Water bodies are typically fine textured

- Grass is medium textured

- Bush is rough textured.

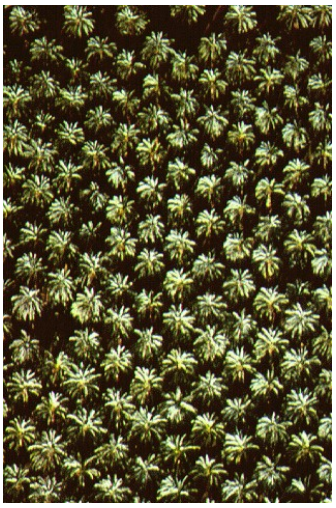
Example of texture is shown below:



ii) **Pattern:** Spatial regular arrangement of objects that can be diagnostic of features on the landscape

- Can be either man-made or natural
- Macro image characteristic

Example of pattern is given below:

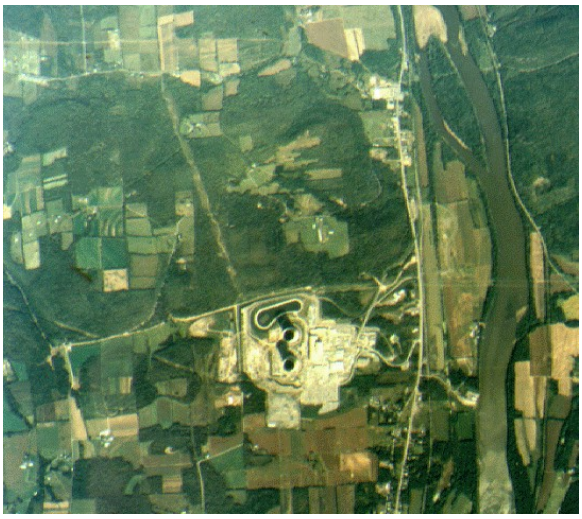


3.1 Third order (Locational or Positional Elements) Elements of Image Interpretation

i) **Site** – Arrangement of objects with respect to one another or with respect to various terrain features

- Distinctive factors of site are aspect, topography, geology, soil, vegetation and cultural features on the landscape
- Relative importance of each of the above distinctive factors vary with local conditions

Example of site:



ii) **Association:** Some objects are so commonly associated with one another that identification of one tends to indicate or confirm the existence of another. E.g:

- Aluminum manufacture requires large amounts of electrical energy. Absence of a power supply may rule out this industry

- Schools have characteristic playing fields, parking lots and clusters of buildings in urban areas

3.2.Third order (Interpreted from lower order elements) Elements of Image Interpretation

i) **Height:** E.g. Measure of deepness of mining excavation indicates the amount of material that was removed

ii) **Shadow** – Results in low sun angle photography

<u>Aids and Techniques of Image Interpretation</u>

- **Collateral Material:**

- Review of existing collateral material (data of many types existing in either analog or digital form) concerning a given area, process; type of facility, or object can aid in the interpretation of remotely sensed data

- Collateral material can be in the form of text, tables, maps, graphs or image data/information

- Material contained within a Geographic Information System (GIS) used to assist an interpreter in an analysis can be considered collateral data

- Two classes of collateral data are of interest:

1. Collateral Data Class: Photo/Image Interpretation Keys

- A set of guidelines used to assist interpreters in rapidly identifying photo/image features

- Selective keys or elimination keys (precise step-wise process that leads to the elimination of all items except the one (ones) that is being identified) are used

2. Collateral Data Class: Field Verification.

- Used to familiarize the interpreter with the area or type of feature or object to be interpreted

Use of Multiple Images

- Multi-Station: Successive overlapping of photographs taken along a given flight line by an aircraft or a satellite.

- Multi-Band: Individual spectral bands within a given region of the EM spectrum (e.g. the red, green, and blue bands of the visible)

- Multi-Spectral: Images from various regions of the EM spectrum (e.g. visible, infrared and microwave)

- Multi-Date: Images of a given area taken at different times

- Multi-Stage: Acquisition of images from platforms flying at different altitudes (e.g. data by low flying aircraft, high flying aircraft and satellite data in a given study)

- Multi-Polarization: Different objects exhibit different rotation to the signal when returned to the sensor

- Multi-Direction: Most sensors employed in remote sensing are aimed vertically except SAR. Sometimes more information can be obtained by using non-vertical viewing angles

- Multi-Enhancement: Many types of enhancement (like optical, electronic, computer assisted, multi-date, multi-band, multi-spectral) are available to the image analyst

- Multi-Disciplinary: Utilizing teams of interpreters with expertise in different disciplines, more information is obtained for a given application

- Multi-Thematic: Many different themes (e.g. hydrology, vegetation, transportation, urban areas, etc.) can be extracted from a single set of images

- Multi-Use: Many persons from different disciplines (e.g. environmental planners, resource managers, public policy decision makers) can use the output of an image interpretation

Methods of Search

Interpretation should

- Be conducted one step at a time

- Begin with the general and proceed to the specific

- Proceed from the known to the unknown

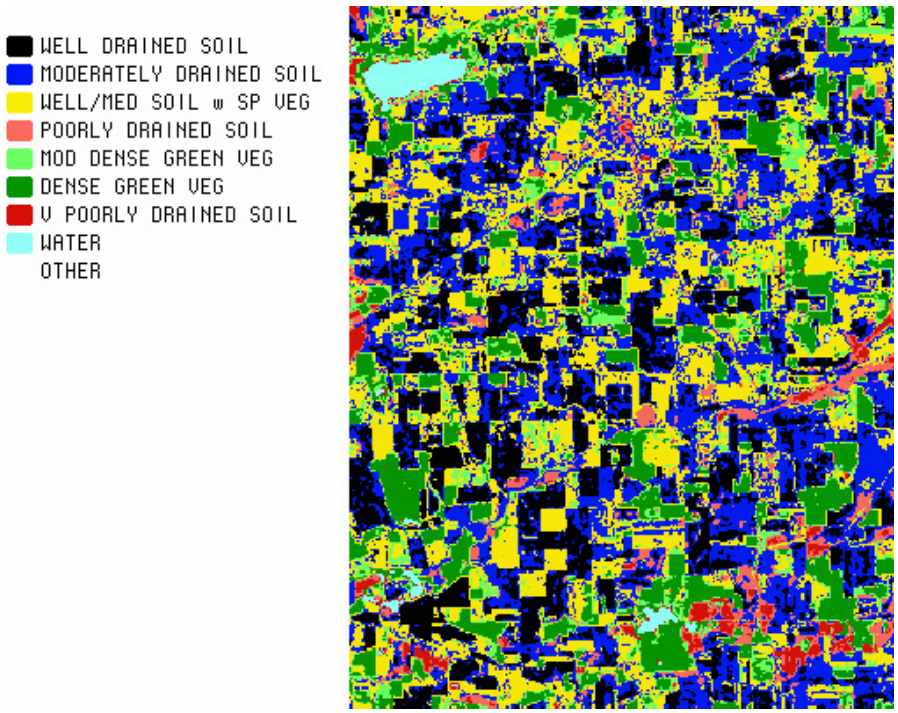
Conclusion and Accuracy of Image Interpretation Results

- Image interpretation is deductive, i.e. features that can be detected and identified lead the interpreter to the location and identification of other features

- Completeness and accuracy of image interpretation, to a certain extent, depend on the understanding of the interpreter on how and why to use certain elements, techniques and methods of interpretation. Overall, image interpretation results are subjective, however can yield practical and economical conclusions in certain dedicated applications.

10.3. CLASSIFICATION

SUPERVISED CLASSIFICATION: Classification schemes use a training area in the image from which a spectral signature is defined. For the spectral signature, the investigator has some prior knowledge. This spectral signature is then extrapolated throughout the image or to another image, to search for other spectrally similar areas. This is known as 'supervised classification'.



Assumptions made in the following classification:

i) The image to be processed is reduced in size to 49 picture elements (pixels), compared to the several millions typical of digital images

ii) Images have only two spectral bands (or dimensions in feature space) whereas a multispectral image may contain in the order of tens, hundreds or even thousands of spectral channels or bands. BAND-1 is red and BAND-2 is portion of the reflective infrared

iii) Number of intensity levels in the image is taken as 10 whereas this is typically 64 to 256 as recorded by a sensor

- A digitized image, 2 bands, 7 x 7 pixel area, line interleaved (first row of first band, first row of second band, second row of first band, ..etc. until seventh row of second band) is given in the below Figure-1

- Image intensity values are given below:

5	3	4	5	4	5	5	5	5	4	6	7	7	7	2	2	3	4	4	4	6	2	4
6	5	5	6	5	2	2	3	3	6	6	8	5	3	5	7	6	6	8	2	2	6	6
9	8	7	3	4	5	6	8	8	7	3	6	8	8	8	7	4	3	5	8	8	8	7
1	3	6	8	7	2	3	2	4	5	8	7	1	0	0	4	6	7	3	3	2	1	3

6	7	0	0	0	0

- Replace in the below Figure-2, the image intensities in Band-1 and Band-2 in the relevant pixels

PIXELS

LINES	1	2	3	4	5	6	7
1	**5**	**3**	**4**	**5**	**4**	**5**	**5**
2	**2**	**2**	**3**	**4**	**4**	**4**	**6**
3	**2**	**2**	**3**	**3**	**6**	**6**	**8**
4	**2**	**2**	**6**	**6**	**9**	**8**	**7**
5	**3**	**6**	**8**	**8**	**8**	**7**	**4**
6	**3**	**6**	**8**	**7**	**2**	**3**	**2**
7	**4**	**6**	**7**	**3**	**3**	**2**	**1**

BAND-1

PIXELS

LINES	1	2	3	4	5	6	7
1	**5**	**5**	**4**	**6**	**7**	**7**	**7**
2	**2**	**4**	**6**	**5**	**5**	**6**	**5**
3	**5**	**3**	**5**	**7**	**6**	**6**	**8**
4	**3**	**4**	**5**	**6**	**8**	**8**	**7**
5	**3**	**5**	**8**	**8**	**8**	**7**	**1**
6	**4**	**5**	**8**	**7**	**1**	**0**	**0**
7	**3**	**6**	**7**	**0**	**0**	**0**	**0**

BAND-2

- For each of the BAND-1 and BAND-2 digital images in Figure-2, transform the numerical values of each pixel into a "shade" of grey according to the following conversion (for simplicity):

Numerical Value	0	1	2	3	4	5	6	7	8	9
Grey Level										

- Replace the above grey shades in Figure-2 and obtain the below Figure-3 Grey maps

PIXELS

LINES	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							

BAND-1

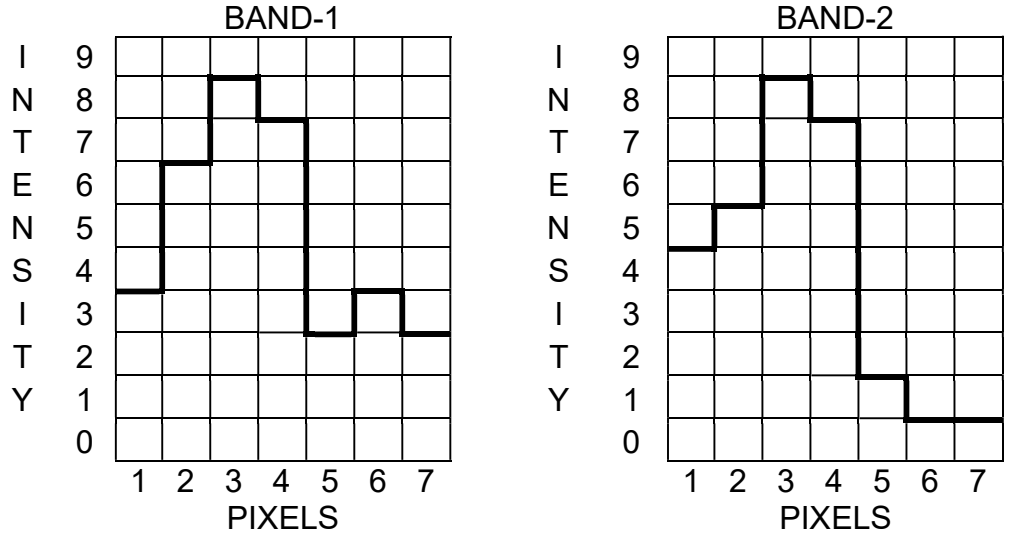
PIXELS

LINES	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							

BAND-2

- An ‘intensity profile’ gives a one-dimensional view of a single cross-section of the data

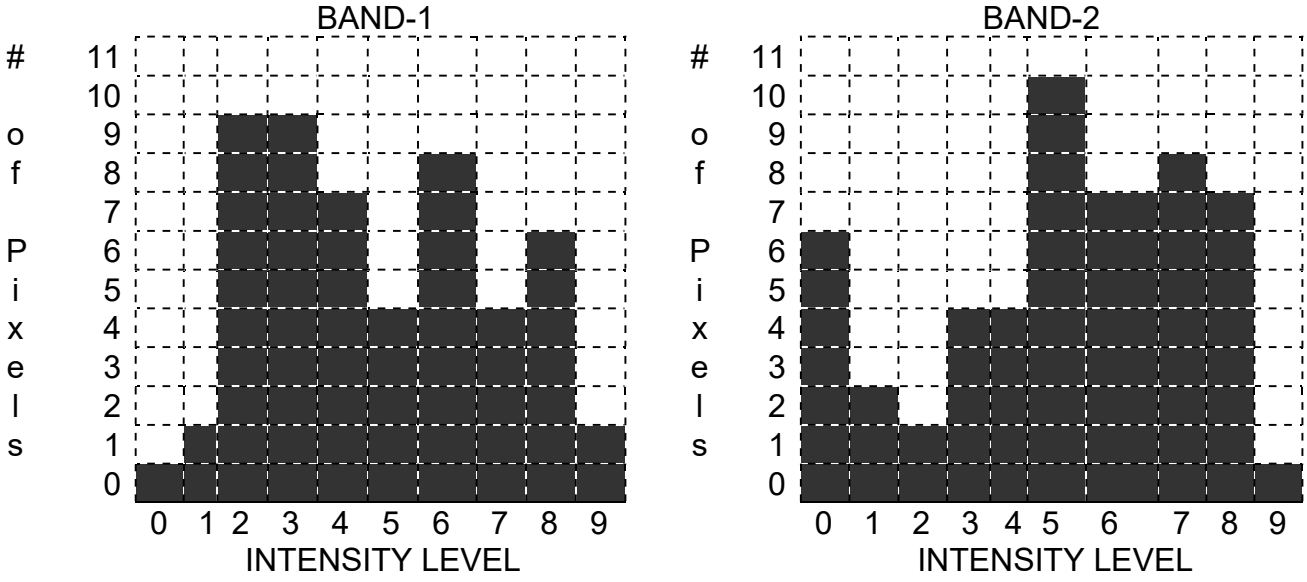
- For example construct an intensity profile for line number 6 of each of the BAND-1 and BAND-2 images. This is given in the below Figure-4



- One-dimensional histogram gives a graphical representation of the data distribution for a single BAND

- For BAND-1, count the number of pixels which have an intensity of zero. Use the digital image in Figure-2. Enter this number in the below Figure-5. Now count the number of times that the intensity level 1 occurs and similarly replace it on Figure-5. Continue for all levels. Check that the sum of these values is 49 (= 7 x 7). Similarly construct the histogram for BAND-2

- Below Figure-5 shows these one-dimensional histograms



Number of pixels:

0	1	9	9	7	4	8	4	6	1

Sum = **49**

Number of pixels:

6	2	1	4	4	10	7	8	7	0

Sum = **49**

- Several observations can be made from these two histograms:

  - Two histograms are significantly different meaning that there is <u>different information</u> in the two bands for the same pixel (or ground area)

  - Note the various peaks of the histograms. Each peak separated from neighbouring peaks by **valleys** is called a **'mode'** of the histogram.

  - Mode corresponds to a particular feature on the ground

  - Presence of several of these modes (a multi-modal histogram) leads to the conclusion that several (different) environmental features are imaged

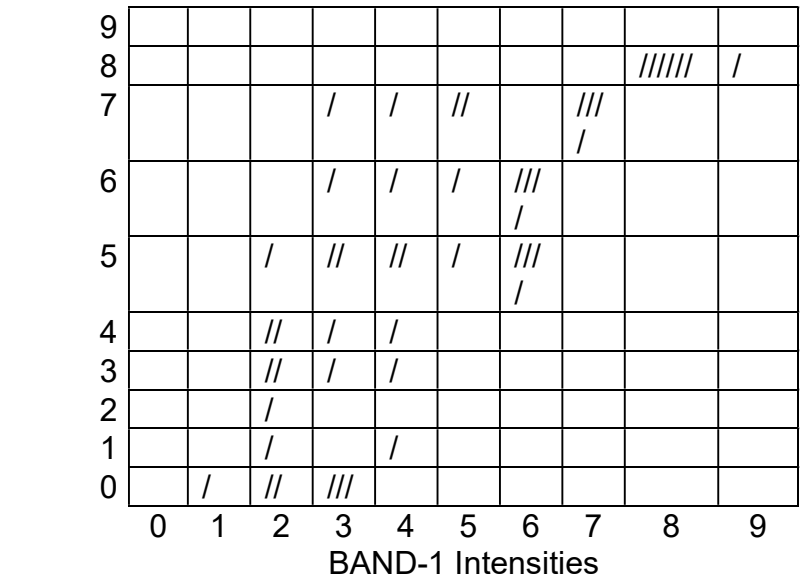
  - Considering BAND-2 histogram, there are two major modes separated by the valley at intensity level 1

  - Since BAND-2 is reflective infrared band, knowledge of the infrared reflection characteristics of land and water can help to identify these two modes. Water strongly absorbs infrared, resulting in low reflectivity. Typically vegetation-covered land surfaces will have high reflection during the summer months. Thus, the assumption is made that the left peak or mode designates water while the large mode on the right is of the land surfaces. By counting the number of pixels in each mode, we already have an idea of the relative size of areas of land and water in the image, even though we haven't seen the image as yet

  - **'Spectral signature'** of any one pixel is the combination of its intensity levels in the two bands. This characteristic can be plotted in a two-dimensional (2-D) histogram

  - Plot the intensity coordinates for each pixel on the below Figure-6. Use the digital maps of Figure-2. When the intensity coordinates for a pixel are found in Figure-6, place a tick mark in the appropriate square.

Figure-6 Two-dimensional histogram.



- Sum these tick marks to find the total in all the pixels.
- 2-Dimensional histogram prepared in this manner in the below Figure-7 will show data distribution of both bands simultaneously.

Figure-7 Two-dimensional histogram.

BAND-2 Intensities

9										
8									**6**	**1**
7				**1**	**1**	**2**		**4**		
6				**1**	**1**	**1**	**4**			
5			**1**	**2**	**2**	**1**	**4**			
4			**2**	**1**	**1**					
3			**2**	**1**	**1**					
2			**1**							
1			**1**		**1**					
0		**1**	**2**	**3**						
	0	1	2	3	4	5	6	7	8	9

BAND-1 Intensities

- Each 'square' or location in the completed 2-D histogram is called a **'cell'** or a **'vector'**
- **2-D histogram** plot is also the **spectral signature** domain
- **Cells which are close to each other in this plot have near-similar spectral characteristics**

CLASSIFICATION USING ONE BAND

- Figure-8 below represents a ground verification map for a particular environmental feature 'forest'

Figure-8 Ground verification map: 'Forest'.

		PIXELS						
		1	2	3	4	5	6	7
L	1						**F**	
I	2					**F**		
N	3							
E	4	**F**						
S	5							
	6							
	7							

- 3 sites are identified on the ground as being forested terrain and the experts who collected this data are further assured that the combination of these three sites is representative of all forest types to be found in the area covered by the remotely sensed image

- Assume that the ground verification map has been geometrically registered to the image, so that the same point on the map and the image can be referenced by 'line' and 'pixel' coordinates

- By using the spectral signature of these **verified** 'forest' areas, one may find all other 'forest' pixels

- This is done by searching all pixels in the scene for similar spectral signatures

- First define the spectral characteristics of the given training sites

- Find the intensities corresponding to each of the 3 test sites for BAND-1

- The category or **class**, **'forest'**, can be assumed to be characterized by the range of intensities found in BAND-1

- Range is defined by the minimum and maximum intensity values from these 3 samples

  - BAND-1 intensity values are 5 , 4 , 2

  - BAND-1 intensity range is minimum: 2 maximum: 5

- Repeat the process for BAND-2

  - BAND-2 intensity values are 7 , 5 , 3

  - BAND-2 intensity range is minimum: 3 maximum: 7

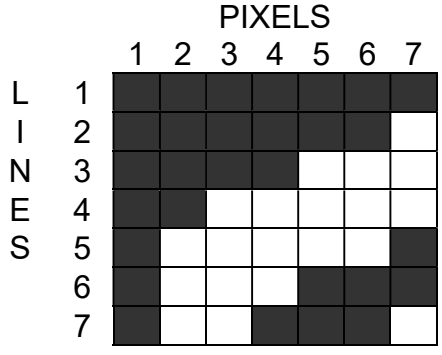
- Classification process now involves searching for all pixels which have an intensity level falling within the range of intensities found in the test sites

- The above is done separately for each band

- So using the BAND-1 digital image of Figure 2, **darken** all of the pixels in the image for intensities falling in the range defined for BAND-1 (i.e. intensities of 2, 3, 4, 5)

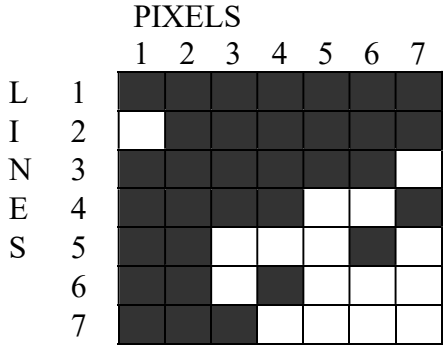
- Thus form the below Figure-9a

Figure-9a Forest map from BAND-1.



- Repeat the process using the BAND-2 digital image of Figure 2 (i.e. darken 3, 4, 5, 6, 7) and thus form the below Figure-9b

Figure-9b Forest map from BAND-2



- The two forest theme maps in Figure-9a and 9b represent the same environmental feature (= forest) but are different because each map was generated using information from one band only

- Procedure used to produce these theme maps is a form of **intensity 'slicing'**. i.e. one specific range of intensities was sliced from the total available range

- More correct classification can be produced if the intensities in both BANDS are considered simultaneously

MULTISPECTRAL CLASSIFICATION (RECTANGULAR)

- In order to classify an image in a multi-spectral (or multi-band) mode, the intensities in all BANDS must be considered simultaneously

- In Figure-l0a, the range of intensities in BAND-1 representing 'forest', is represented by the shaded area from BAND-1 intensity 2 to 5 inclusive

- Similarly in Figure-10a for BAND-2, 'forest' is represented by the shaded area of intensities 3 to 7 inclusive

- The overlap of these two individual intensity ranges in this two-dimensional diagram is a cross-hatched area representing the multispectral (rectangularly-defined) spectral signature of 'forest'

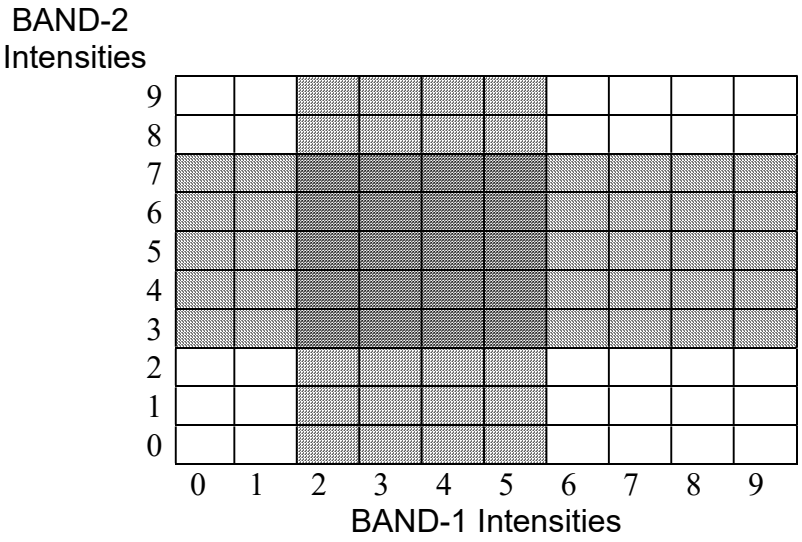
- In order to produce a multispectral classification of 'forest', it is necessary to find all pixels of the image whose spectral coordinates fall inside the cross-hatched rectangular area

- Using the digital images of Figure 2, scan all pixels for BAND-1 intensities of 2, 3, 4, or 5

- When a pixel has one of these BAND-1 intensities, check if its BAND-2 intensity is 3, 4, 5, 6 or 7

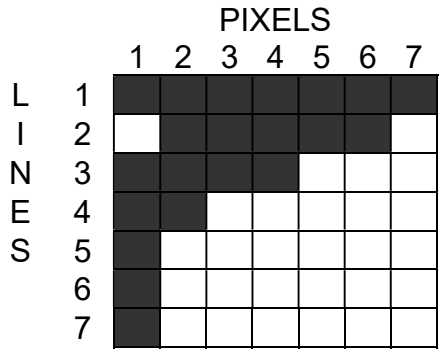
- If a pixel agrees with <u>both</u> of these criteria, then shade in the corresponding pixel in Figure-10b

Figure-10a Feature space portion representing 'Forest'.



- Forest map of below Figure-l0b is the logical overlap between forest maps 9a and 9b

Figure-10b 'Forest' theme from BAND-1 and BAND-2



TO SUMMARIZE:

- Rectangular multispectral classification requires **'representative samples'** of the environmental feature to be mapped

- Intensities of these sample pixels are collected in each band

- The range of intensities which correspond to the feature of interest is plotted as spectral band versus spectral band **(feature space)**

- The **rectangle** thus defined in two-dimensional feature space is the **spectral signature** of the environmental feature

- When more than two dimensions are used (e.g. hundreds of bands on airborne multispectral sensors) then N-bands can produce an N-dimensional **'rectangular parallelepiped' spectral signature**

MULTISPECTRAL CLASSIFICATION (VECTOR)

- Further refinement of the spectral signature, as defined by rectangular multispectral classification, is possible

- To illustrate this refinement, basic limitation of the rectangular classification technique is demonstrated below

- Forest map of Figure-l0b is verified on the ground by visual inspection and homogeneous stands of **C**oniferous and **D**eciduous forests are identified

- Below Figure-11a shows the spatial distribution of these two forest types

Figure-11a Ground verification map: 'Forest Types'.

		PIXELS						
		1	2	3	4	5	6	7
L	1	**D**			**D**	**D**	**D**	**D**
I	2		**C**				**D**	
N	3	**C**	**C**		**D**			
E	4	**C**	**C**					
S	5	**C**						
	6	**C**						
	7	**C**						

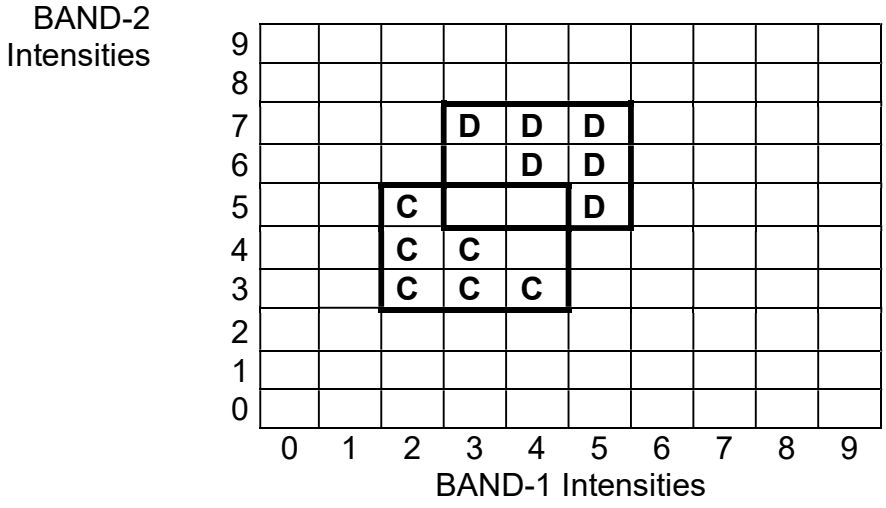
where **'C**' = **C**oniferous and '**D**' = **D**eciduous

- In order to delineate the portions of spectral feature space which correspond to each of the two forest types:

  - For each pixel identified in the ground verification map of Figure-11a, find the corresponding BAND-1 and BAND-2 intensities in Figure 2

  - Plot each such spectral coordinate in the below Figure-11b using symbols **'C'** (**C**oniferous) and **'D'** (**D**eciduous)

Figure-11b Forest type designation in feature space.



- Draw a rectangle to define the spectral signature of '**C**oniferous forest'
- Two vertical sides of this rectangle are the lower and upper limits of the range of intensities for BAND-1
- Top and bottom lines of the rectangle are the upper and lower limits of the range of intensities for BAND-2
- Draw a similar rectangle for the spectral signature of '**D**eciduous forest'
- Note that the two rectangles **partially overlap**

- It is this overlapping of spectral signatures in feature space which is a major **limiting factor to the usefulness of the rectangular classification** method

- If a particular pixel has spectral coordinates which fall into the overlap region, then one is at a loss whether to label this pixel as '**C**oniferous' or '**D**eciduous'

- **Multispectral vector classifier** looks inside any feature space rectangle to identify each spectral coordinate (also known as "cell" or 'vector') and the number of pixels which are associated with each coordinate

- This defines the **data density distribution in feature space**

- Use a multispectral vector classification scheme to map coniferous and deciduous forests in **another scene**

- First scene is used in Figure-11a and 11b to 'train' the classifier

- İ.e: First scene contains the test sites from which the spectral signatures of the two forest types are defined

- These spectral signatures can be extrapolated to another area (scene No. 2) to look for similar environmental features

- Figures-12a and 12b below contain the digital images of BAND-1 and BAND-2 of the new scene (No. 2)

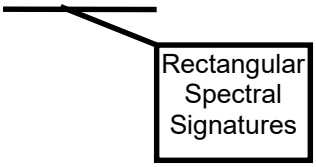
- Figure-12c is the feature space representation of the spectral signatures of **C**oniferous (**C**) and **D**eciduous (**D**) forests

- Scan the new scene pixel by pixel

- In order to classify any one pixel as one of the two forest types, it must agree in BAND-1 and BAND-2 intensities with one of the cells in Figure-12c, which is marked '**C**' or '**D**'

- It is **NOT** sufficient for the spectral coordinates to merely fall within the rectangular limits

- It is mandatory that the spectral coordinates being considered coincide with a cell marked by '**C**' or '**D**'



- Only in this manner will ambiguities related to the overlap region be avoided

- Those pixels thus identified in Figure-12c should be marked appropriately as '**C**' or '**D**' on the theme map of Figure-12d

Shown below is Figure-12a Scene #2, BAND-1.

		PIXELS						
		1	2	3	4	5	6	7
L	1	**3**	**4**	**1**	**1**	**2**	**2**	**2**
I	2	**4**	**4**	**4**	**2**	**1**	**2**	**2**
N	3	**3**	**3**	**5**	**2**	**2**	**2**	**2**
E	4	**5**	**5**	**2**	**2**	**2**	**2**	**2**
S	5	**4**	**5**	**5**	**2**	**2**	**2**	**2**
	6	**4**	**3**	**3**	**4**	**4**	**5**	**5**
	7	**5**	**5**	**3**	**4**	**4**	**5**	**4**

Shown below is Figure-12b Scene #2, BAND-2.

		PIXELS						
		1	2	3	4	5	6	7
L	1	**7**	**7**	**0**	**0**	**0**	**3**	**3**
I	2	**7**	**7**	**6**	**0**	**0**	**3**	**4**
N	3	**4**	**4**	**7**	**1**	**1**	**3**	**4**
E	4	**7**	**7**	**4**	**4**	**3**	**4**	**4**
S	5	**6**	**7**	**7**	**4**	**5**	**5**	**5**
	6	**7**	**5**	**5**	**5**	**7**	**7**	**6**
	7	**7**	**6**	**6**	**7**	**7**	**7**	**7**

Shown below is Figure-12c Scene #2, feature space

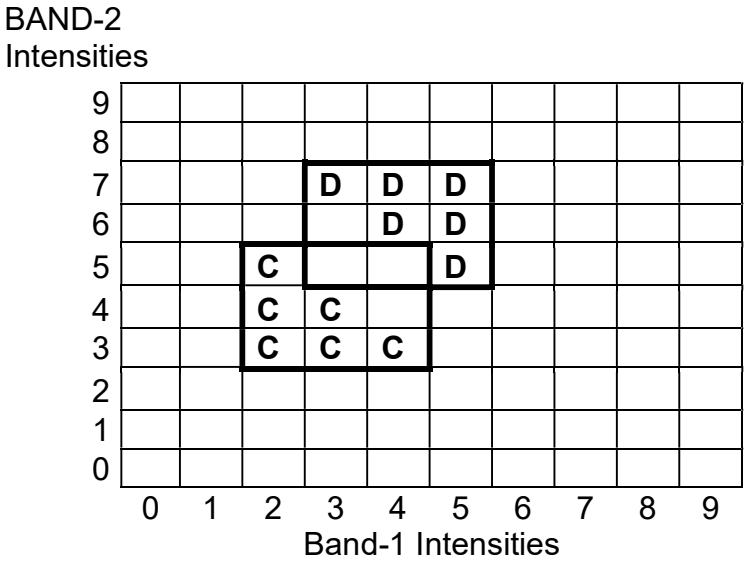


Figure-12d Scene #2, theme map

		PIXELS						
		1	2	3	4	5	6	7
L	1	**D**	**D**				**C**	**C**
I	2	**D**	**D**	**D**			**C**	**C**
N	3	**C**	**C**	**D**			**C**	**C**
E	4	**D**	**D**	**C**	**C**	**C**	**C**	**C**
S	5	**D**	**D**	**D**	**C**	**C**	**C**	**C**
	6	**D**				**D**	**D**	**D**
	7	**D**	**D**		**D**	**D**	**D**	**D**

'C' = Coniferous Forest
'**D'** = Deciduous Forest

- The above procedure is called: '**N-dimensional training**', to refer to the fact that the intensities of **more than one band** are considered simultaneously

- This type of training and classification scheme is also known as '**non-parametric'** in that the **absolute location of spectral coordinates** in feature space is the criterion for defining an environmental feature, and **NOT statistical parameters** such as mean and standard deviation

INTERPRETATIONS FROM SPECTRAL SIGNATURES

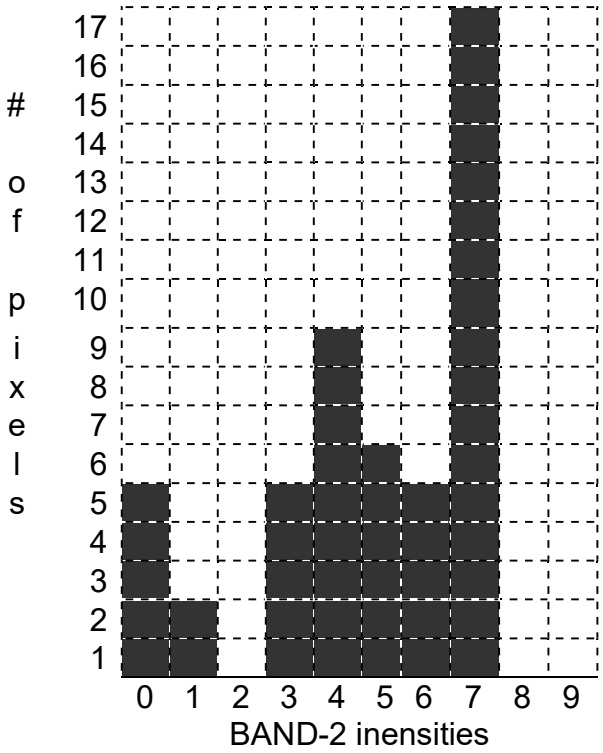
- Ground verification is essential in assigning environmentally valid names to features found on an image

- However, it is appropriate to make deductions concerning an unverified feature, from its spatial and spectral characteristics

- As studied before, one-dimensional histogram of the infrared BAND-2 displays a marked difference between a low intensity mode corresponding to water and a high intensity mode corresponding to land features

- This can be observed on the one-dimensional histogram of BAND-2 of **scene No. 2**, plotted in below Figure-13a

FIGURE-13a Scene #2, BAND-2, one-dimensional histogram.



- The left mode of the histogram comprising BAND-2 intensities less than 2 will relate to water pixels to a high degree of certainty

- The major conflicting phenomenon would be shadow areas due to clouds or mountains which would also result in low intensities

- Find those pixels in Figure-12b which have intensities less than 2 and mark the corresponding pixels in Figure-12d as **W**ater: **'W'**. This is shown below:

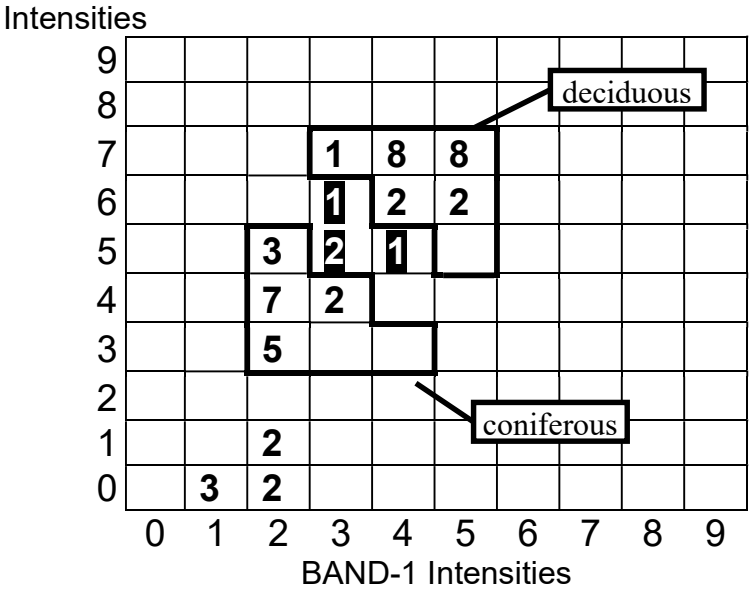
Figure-12d with **'W'** added

		PIXELS						
		1	2	3	4	5	6	7
L	1	**D**	**D**	**W**	**W**	**W**	**C**	**C**
I	2	**D**	**D**	**D**	**W**	**W**	**C**	**C**
N	3	**C**	**C**	**D**	**W**	**W**	**C**	**C**
E	4	**D**	**D**	**C**	**C**	**C**	**C**	**C**
S	5	**D**	**D**	**D**	**C**	**C**	**C**	**C**
	6	**D**				**D**	**D**	**D**
	7	**D**	**D**		**D**	**D**	**D**	**D**

'W': Water:

- Portions of feature space which were previously defined as representing coniferous and deciduous forest are indicated in the below Figure 13b

Figure-13b Scene #2, two-dimensional histogram



- It is reasonable to assume that the portion of feature space which lies between two specific spectral signatures, may represent a mixed environmental target

- Thus, the cells lying between the areas shown as ‘coniferous’ and ‘deciduous’ may be the spectral representation of the mixture of these two forest types, namely mixedwood

- Identify the pixels which are represented by these cells which may be mixedwood (there are 3 of these cells marked as black in Figure-13-b)

- Mark these cells on Figure-12d as **‘M’** denoting **M**ixedwood

- Verify that the correct number of pixels have been identified as mixedwood by summing the frequencies of occurrance of the intensity levels of the three cells in Figure-13b (1 + 2 + 1 = 4 each of **‘M’** should be marked. This is shown below:

Figure-12d with **‘M’** added

		PIXELS						
		1	2	3	4	5	6	7
L	1	**D**	**D**	**W**	**W**	**W**	**C**	**C**
I	2	**D**	**D**	**D**	**W**	**W**	**C**	**C**
N	3	**C**	**C**	**D**	**W**	**W**	**C**	**C**
E	4	**D**	**D**	**C**	**C**	**C**	**C**	**C**
S	5	**D**	**D**	**D**	**C**	**C**	**C**	**C**
	6	**D**	**M**	**M**	**M**	**D**	**D**	**D**
	7	**D**	**D**	**M**	**D**	**D**	**D**	**D**

‘M’= Mixedwood

UNSUPERVISED CLASSIFICATION

- Previous classification schemes used a training area in the image from which a spectral signature was defined and for which the investigator had some prior knowledge

- This spectral signature is then extrapolated throughout the image or to another image by searching spectrally similar areas

- This is known as a variation of ‘supervised classification’

- Sometimes, it is preferred to **reverse the procedure**

- It is sometimes useful to delineate spectrally dissimilar areas of an image even when nothing is known about the environmental character of the resulting subdivisions or classes

- These classes are then mapped and the map taken into the field to identify the classes

- This procedure is known as ‘**unsupervised classification’** since no training sites are involved

- Main advantage unsupervised classification is that the classes are subdivided based on their **statistical** characteristics usually covering **large** geographical areas, rather than depending on a ‘training sample’ which may be quite unrepresentative of the class variability over the whole scene to be mapped

- An algorithm will be used below that relies on finding areas of high pixel density (in feature space) which are separated by regions of low density

- The feature space representation (Figure-13b) of scene No. 2 is reproduced in the below Figure-14a

Figure-14a Scene #2, feature space

BAND-2 Intensities

9										
8										
7				**1**	**8**	**8**				
6				**1**	**2**	**2**				
5			**3**	**2**	**1**					
4			**7**	**2**						
3			**5**							
2										
1			**2**							
0		**3**	**2**							
	0	1	2	3	4	5	6	7	8	9

BAND-1 Intensities

- Copy those cells from Figure-14a, which have a count of (density) 3 or more Into the below Figure-14b

Figure-14b Scene #2, feature space with count of (density) 3 or more

BAND-2
Intensities

9										
8										
7					**8**	**8**				
6										
5			**3**							
4			**7**							
3			**5**							
2										
1										
0		**3**								
	0	1	2	3	4	5	6	7	8	9

BAND-1 Intensities

- 3 clusters of high density cells are observed in the above Figure-14b (Scene #2, feature space with count of (density) 3 or more)

- These groupings of high density cells are each only the nucleus of a cluster

- Next step is to define the boundaries of each whole cluster

- Cluster with a nucleus of two cells will be called **cluster 'A'** in feature space and **class 'A'** when it is finally mapped geographically (by line and pixel)

- Identify each cell which touches the nucleus cells of cluster 'A', by marking such cells with the letter 'A'

- There should be l0 such cells marked, counting even those cells which touch with a corner only. This is shown below:

BAND-2
Intensities

9										
8				**A**	**A**	**A**	**A**			
7				**A**	**8**	**8**	**A**			
6				**A**	**A**	**A**	**A**			
5			**3**							
4			**7**							
3			**5**							
2										
1										
0		**3**								
	0	1	2	3	4	5	6	7	8	9

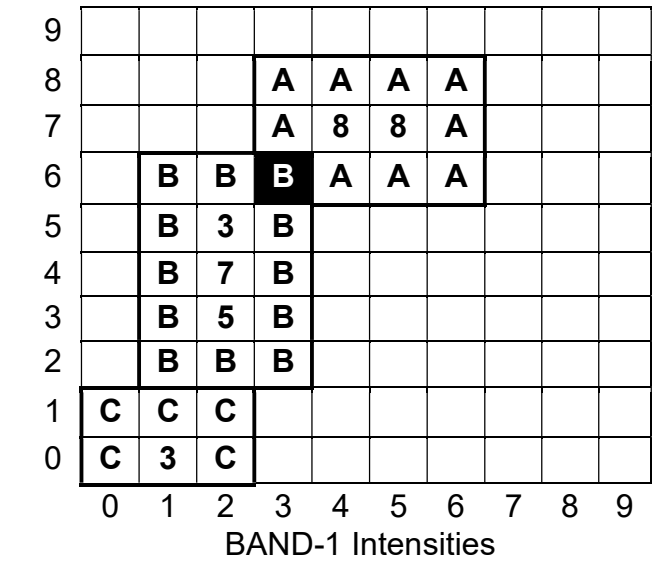
BAND-1 Intensities

- Repeat the process for cluster ‘B’ (with three nucleus cells) using the letter ‘B’ for the neighbouring cells, and also for cluster ‘C’ (with one nucleus cell) and using the letter ‘C’

- There will be a point of ambiguity where two clusters overlap and a cell (dark cell in the below Figure-14b) is identified as belonging to the neighbourhood of two clusters

- A decision must be forced, so identify this conflict cell (dark cell in the below Figure-14b) as belonging to the cluster with the <u>larger</u> nucleus

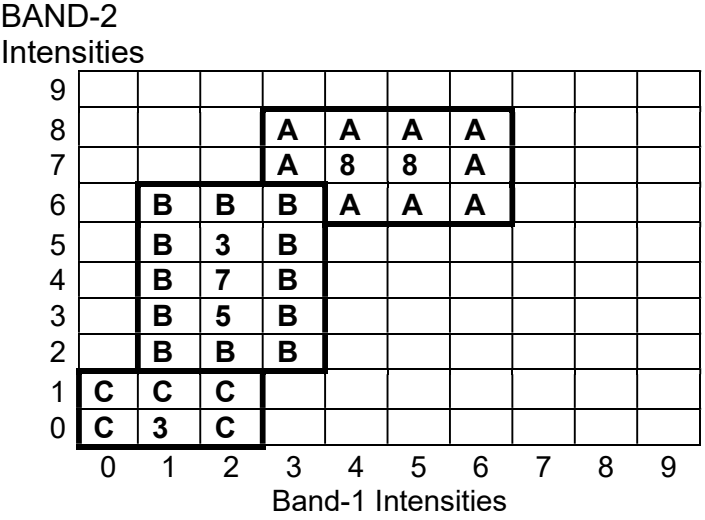
Figure-14b with all the clusters ‘A’ , ‘B’ and ‘C’



- Draw the boundary for <u>each</u> cluster enclosing its complete neighbourhood in Figure-14b

- There are 11 cells inside the boundary for cluster ‘A’, 15 cells in cluster ‘B’ and 6 cells in cluster ‘C’. This is shown in the below Figure-14b (Scene #2, feature space with boundaries) Transfer just the boundaries back to the original feature space in Figure-14a

Figure-14b Scene #2, feature space with boundaries



- Transfer those cells in Figure-14a, which fall inside the boundary for cluster ‘A’ and which display a count or density of 1 or greater, into the below Figure-14c, and identify those cells by the letter ‘A’

- Repeat the procedure for clusters ‘B’ and ‘C’ using the appropriate designation

Figure-14c Scene #2, feature space showing the clusters

BAND-2
Intensities

9										
8										
7				A	A	A				
6				B	A	A				
5			B	B						
4			B	B						
3			B							
2										
1			C							
0		C	C							
	0	1	2	3	4	5	6	7	8	9

BAND-1 Intensities

- Next step is to map these clusters into their geographical locations

- For each pixel, spectral coordinates of Figure-14d are obtained from the digital maps of Figures-12a and 12b

- These coordinates are located in Figure-14c and the classification symbol (A, B, or C) are allocated to the relevant pixel in the below Figure-14d

Figure-14d Scene #2, unsupervised classification

		PIXELS						
		1	2	3	4	5	6	7
L	1	**A**	**A**	**C**	**C**	**C**	**B**	**B**
I	2	**A**	**A**	**A**	**C**	**C**	**B**	**B**
N	3	**B**	**B**	**A**	**C**	**C**	**B**	**B**
E	4	**A**	**A**	**B**	**B**	**B**	**B**	**B**
S	5	**A**	**A**	**A**	**B**	**B**	**B**	**B**
	6	**A**	**B**	**B**		**A**	**A**	**A**
	7	**A**	**A**	**B**	**A**	**A**	**A**	**A**

- It is required that the individual classes (A, B, C) of unsupervised classification shown in Figure-14d are identified environmentally

- Identification can be done in various ways: airphoto interpretation or actually visiting the site, if practical

- However, it is not necessary to completely cover the relevant scene

- Another advantage of the unsupervised classification scheme is that it can direct fieldwork or other forms of ground verification, to convenient, small and representative locations, where environmentally valid names may be assigned to the classes

- E.g. the location marked by an asterisk in Figure 14D would be a suitable location to identify classes ‘A’, ‘B’, and ‘C’ because of their proximity to each other

- Just a few such locations need to be investigated for a large scene, in order to be able to name the classes with confidence

- Also, during ground verification, those areas which are ‘unclassified’ (such as pixel No. 4, line No. 6 on Figure-14d) can be identified

- These unclassified areas can also be due to imperfections in the processing technique or a ‘noisy’ image

IMAGE ENHANCEMENT

- Image enhancement techniques make an image easier to analyze and interpret

- A common problem in remote sensing is that the range of reflectance values collected by a sensor may not match the capabilities of the display device

Image Reduction

- It is often necessary to locate the exact row and column coordinates of a study area within an image

- Many digital image processing systems are unable to display a full image at the normal commercial pixel scale (>3000 rows and 3000 columns)

- This brings can a problem in locating the exact coordinates of a study area

- Under such circumstances, image reduction allows the analyst to view a subset of an image at one time on the screen by reducing the original image dataset down to a smaller dataset

- Image reduction is useful for orientation purposes as well as fixing the exact row and column coordinates of an area of interest

- Digital image is reduced to $1/m^2$ of the original data if every other m^{th} row and every other m^{th} column of the image are selected

- E.g: if m=2 then the reduction will create a sampled image which consists only 25% of the pixels found in the original scene

- Reduction by m=2 is shown in the below Figure