

# Image Classification I

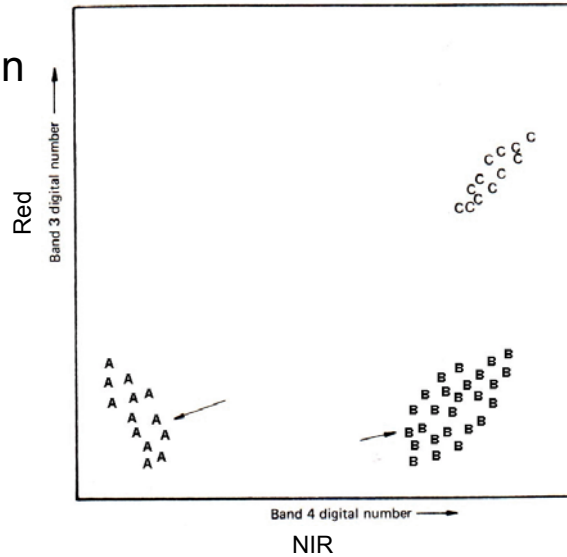
- Classification is the process of labeling image pixels using predetermined categorical classes.
- Components:
  - Image features
  - Classification scheme
  - Signatures
  - Training
  - Classifiers

# Classification Components

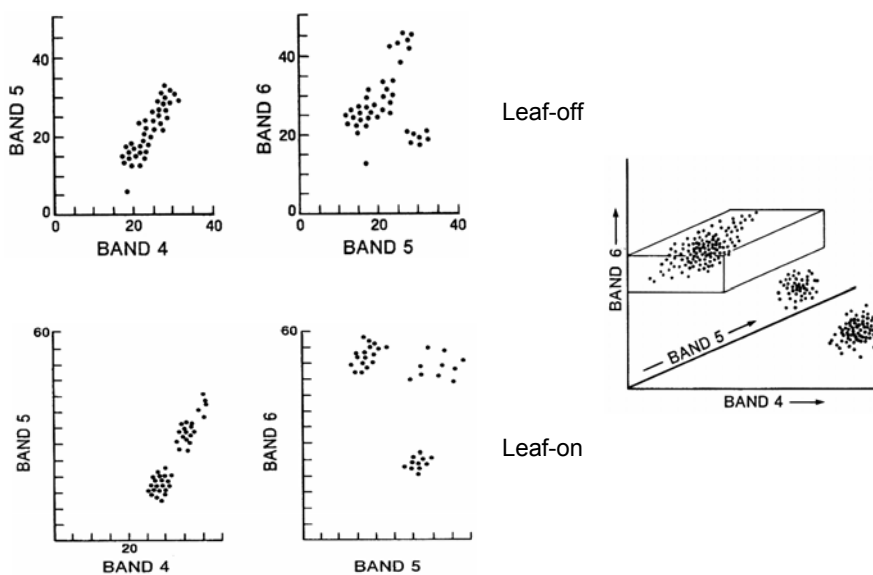
- Features/Feature space/Dimensionality
  - Spectral bands, textures, indices, ancillary GIS layers...
- Classification schemes
  - Taxonomically correct definitions of classes organized according to logical criteria (e.g., 1976 USGS Anderson's classification)
  - Hard vs soft classification schemes
- Signatures
  - Informational classes and spectral classes
- Training
  - Process for extracting signatures of information classes
- Classifier
  - A procedure to assign pixels to classes based on feature space distance and class signatures

What land-cover are these?

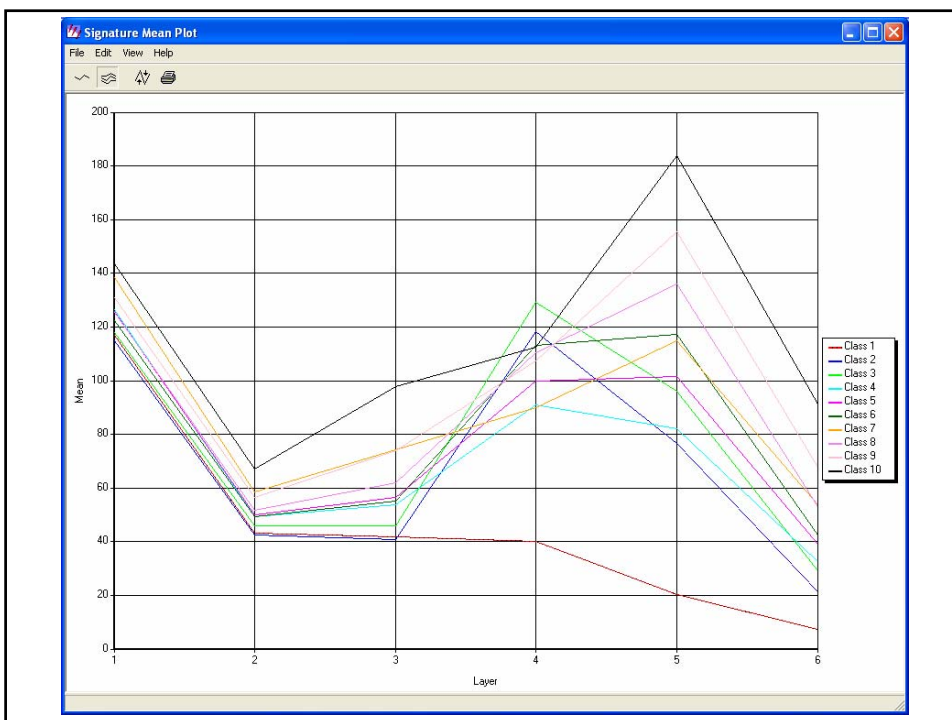
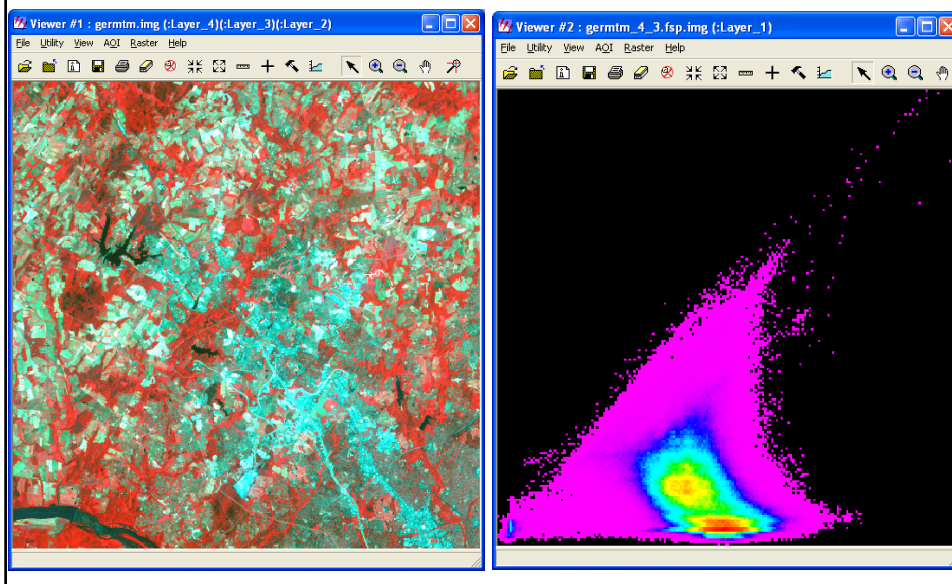
- A : Water
- B : Vegetation
- C : Dry soil

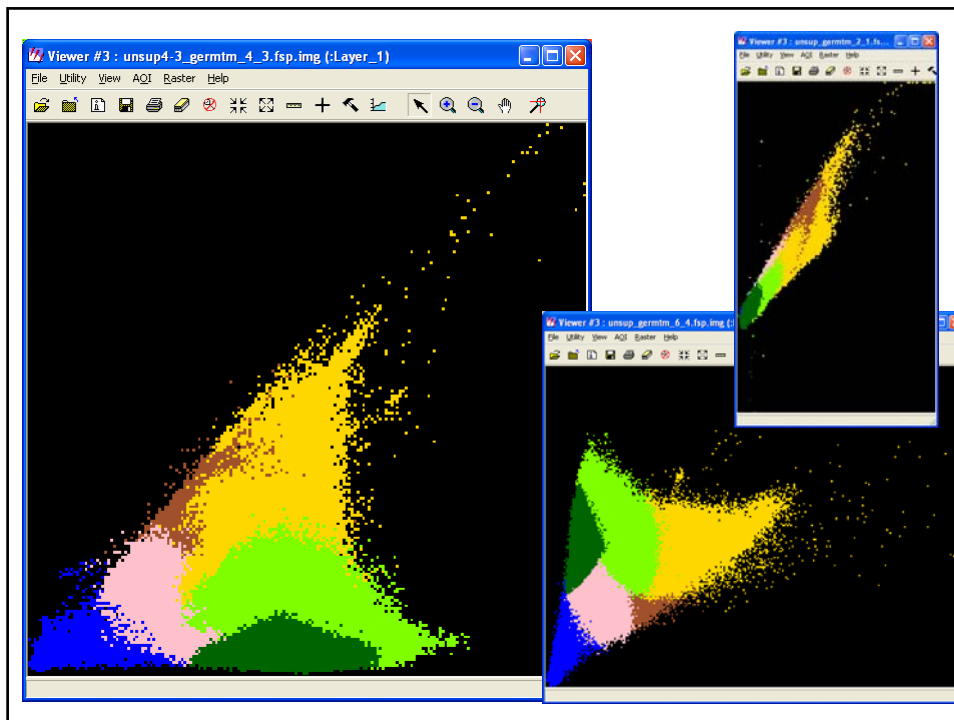


## Class Separability



# Feature Space





## Anderson Classification: Land-Use/Land-Cover

**Level 1**  
1. Urban or built-up

**Level II**  
11. Residential

**Level III**  
111. Single-family Units  
112. Multi-family Units  
113. Group Quarters  
114. Residential Hotels  
115. Mobile Home Parks  
116. Transient Lodging  
117. Other

### Class Definitions:

#### 4. FOREST LAND

- Forest Lands have a tree-crown areal density (crown closure percentage) of 10 percent or more, are stocked with trees capable of producing timber or other wood products, and exert an influence on the climate or water regime....

#### 41. DECIDUOUS FOREST LAND

- Deciduous Forest Land includes all forested areas having a predominance of trees that lose their leaves at the end of the frost-free season or at the beginning of a dry season....

## Levels I & II Anderson Classification

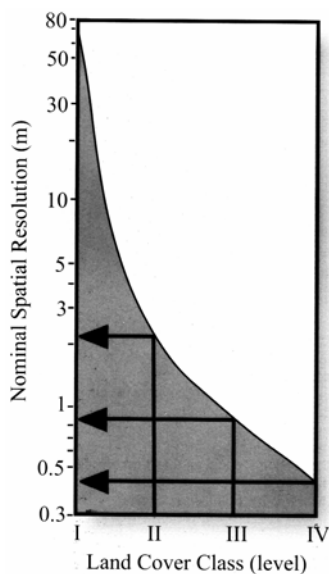
### Level I

- 1 Urban or Built-up Land
- 2 Agricultural Land
- 3 Rangeland
- 4 Forest Land
- 5 Water
- 6 Wetland
- 7 Barren Land
- 8 Tundra
- 9 Perennial Snow or Ice

### Level II

- 11 Residential
- 12 Commercial and Services
- 13 Industrial
- 14 Transportation, Communications, and Utilities
- 15 Industrial and Commercial Complexes
- 16 Mixed Urban or Built-up Land
- 17 Other Urban or Built-up Land
- 21 Cropland and Pasture
- 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas
- 23 Confined Feeding Operations
- 24 Other Agricultural Land
- 31 Herbaceous Rangeland
- 32 Shrub and Brush Rangeland
- 33 Mixed Rangeland
- 41 Deciduous Forest Land
- 42 Evergreen Forest Land
- 43 Mixed Forest Land
- 51 Streams and Canals
- 52 Lakes
- 53 Reservoirs
- 54 Bays and Estuaries
- 61 Forested Wetland
- 62 Nonforested Wetland
- 71 Dry Salt Flats
- 72 Beaches
- 73 Sandy Areas other than Beaches
- 74 Bare Exposed Rock
- 75 Strip Mines Quarries, and Gravel Pits
- 76 Transitional Areas
- 77 Mixed Barren Land
- 81 Shrub and Brush Tundra
- 82 Herbaceous Tundra
- 83 Bare Ground Tundra
- 84 Wet Tundra
- 85 Mixed Tundra
- 91 Perennial Snowfields
- 92 Glaciers

## Anderson Classification & Spatial Resolution



### Classification Level

### Typical Data Characteristics

I

Satellite imagery such as NOAA AVHRR (1.1 × 1.1 km), MODIS (250 × 250 m; 500 × 500 m), Landsat MSS (79 × 79 m), Landsat Thematic Mapper (30 × 30 m), and SPOT XS (20 × 20 m).

II

Satellite imagery such as SPOT HRV multispectral (10 × 10 m) and Indian IRS 1-C panchromatic (5 × 5 m). High-altitude aerial photography acquired at scales smaller than 1:80,000.

III

Satellite imagery with 1 × 1 m to 2.5 × 2.5 m nominal spatial resolution. Medium-altitude aerial photography at scales from 1:20,000 to 1:80,000.

IV

Satellite imagery with ≤ 1 × 1 m nominal spatial resolution (e.g., Quick-Bird, IKONOS). Low-altitude aerial photography at scales from 1:4,000 to 1:20,000 scale.

## Digital Image Classification Procedures

- Preprocessing
- Selecting features (e.g., spectral bands)
- Extracting signatures
  - Supervised versus unsupervised
- Classifying image entities using a classifier
  - Parallelepiped, minimum distance, maximum likelihood, Bayesian, Fuzzy,...
- Performing accuracy assessment

## Further Considerations

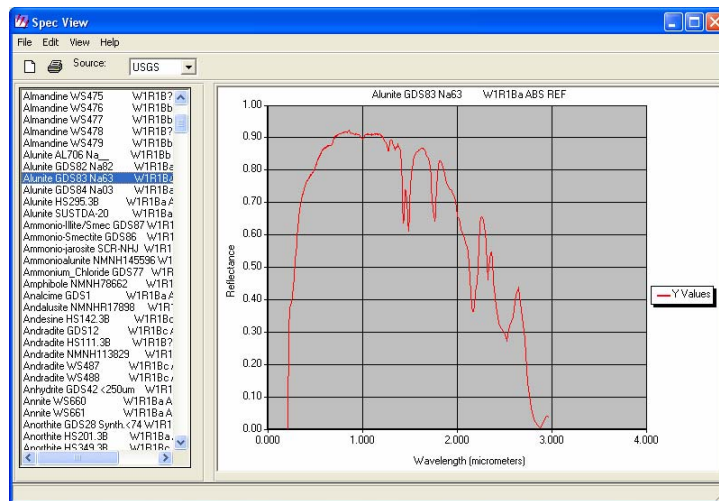
- Pixel-based or object-based
- Multi-spectral or hyper-spectral



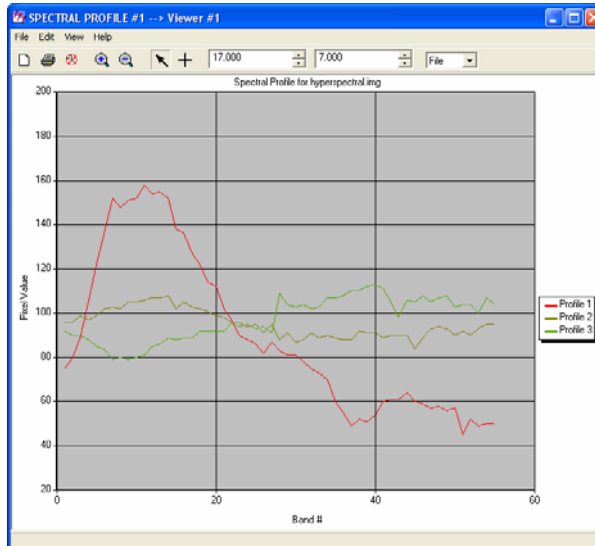
# ECHO

- Extraction and Classification of Homogeneous Objects (ECHO)
- Object-oriented image segmentation & classification (e.g., eCognition by Definiens Inc)
- Allows the use of more interpretation elements such as texture, shape, size...

## Hyperspectral Classification Spectral Library & Reflectance Spectrum



## Comparison of Reflectance Spectra (Spectral Feature Fitting)



## Signatures

- Parametric
  - signature that is based on statistical parameters (e.g., mean, min, max, stdv, variance, and covariance matrix) of the pixels that are in the training sample or cluster.
- Nonparametric
  - signature that is not based on statistics, but on discrete objects (polygons or rectangles) in a feature space image. These feature space objects are used to define the boundaries for the classes.

Parametric and nonparametric classifiers

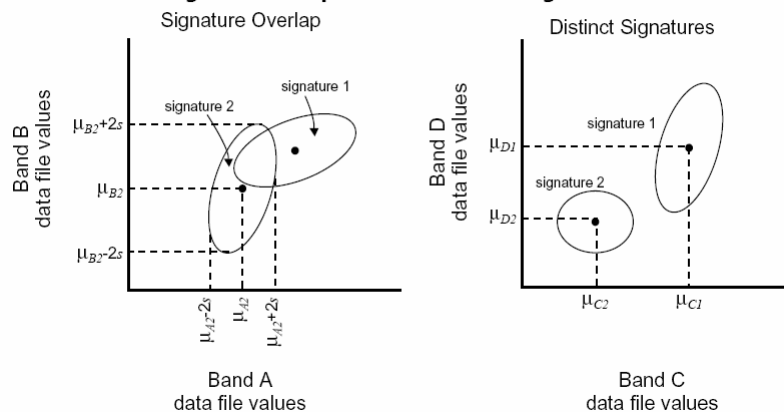


## Ways of Generating Class Signatures

- Clustering
  - Generates spectral classes
  - Unsupervised classification
- Manual Training
  - Training sites
  - Generates informational classes
  - Supervised classification

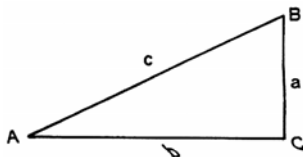
## Signature Separability

**Figure 99: Ellipse Evaluation of Signatures**



# Classifier

- Aka classification algorithms, decision rules
- Distance
  - Euclidean distance
- Probability

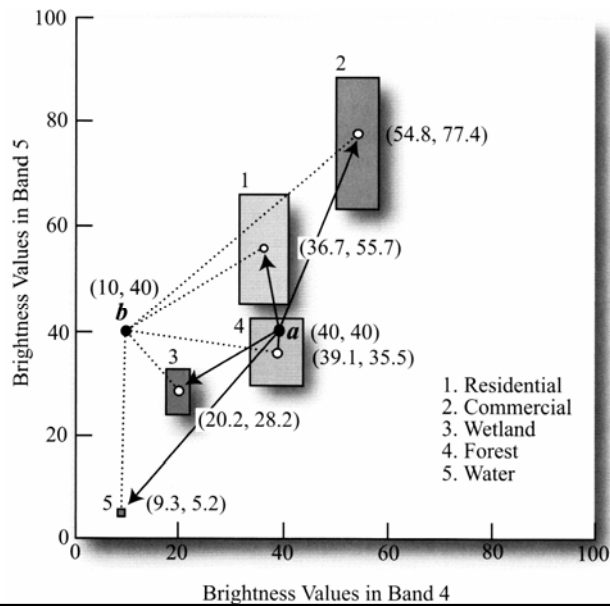


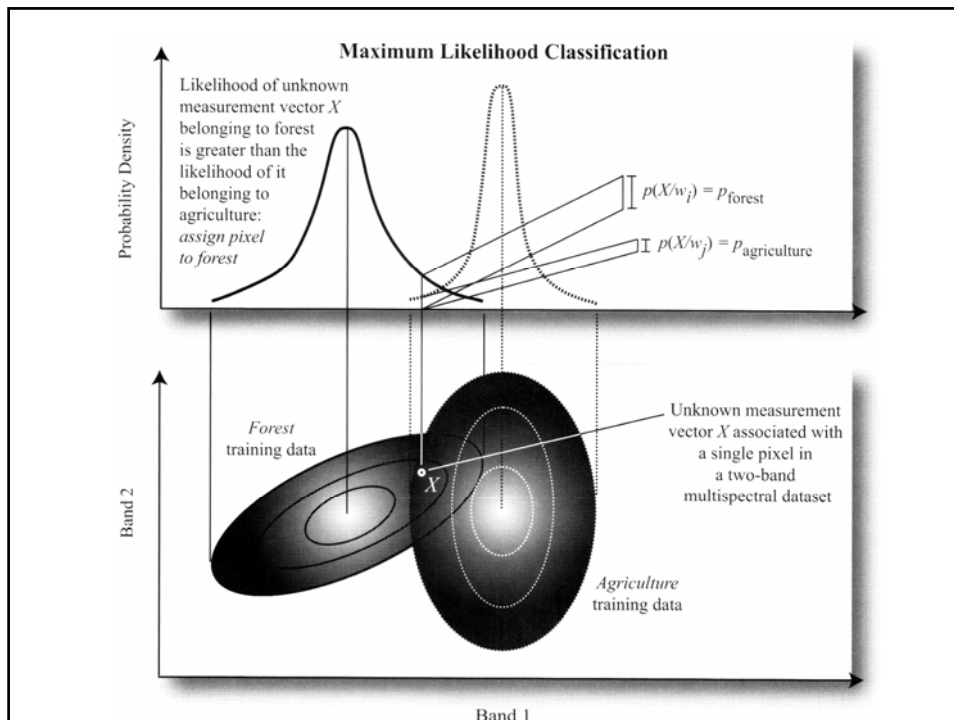
$$c^2 = a^2 + b^2$$

$$c = \sqrt{a^2 + b^2}$$

	Landsat MSS band			
	1	2	3	4
Pixel A	34	28	22	6
Pixel B	26	16	52	29
Difference	8	12	-30	-23
(Difference) <sup>2</sup>	64	144	900	529
Total of (differences) <sup>2</sup> = 1,637				
$\sqrt{\text{total}} = 40.5$				

## Parallelepiped & Minimum Distance Classifiers





## Unsupervised Classification

- Identifies the natural groups (i.e., spectral classes) within multi-spectral data.
- Advantages
  - No prior knowledge is required
  - Human error is minimized
  - Unique classes are recognized
- Disadvantages
  - Spectral classes  $\neq$  information classed
  - Additional labeling is required
  - Spectral properties vary over time, across images

## Unsupervised Classification Procedures

- Generates spectral class signatures and assigns pixels to spectral classes iteratively (ISODATA).
- Maps spectral classes to information classes
- Regroups pixels into information classes

## ISODATA

Iterative Self-Organizing  
Data Analysis Technique

