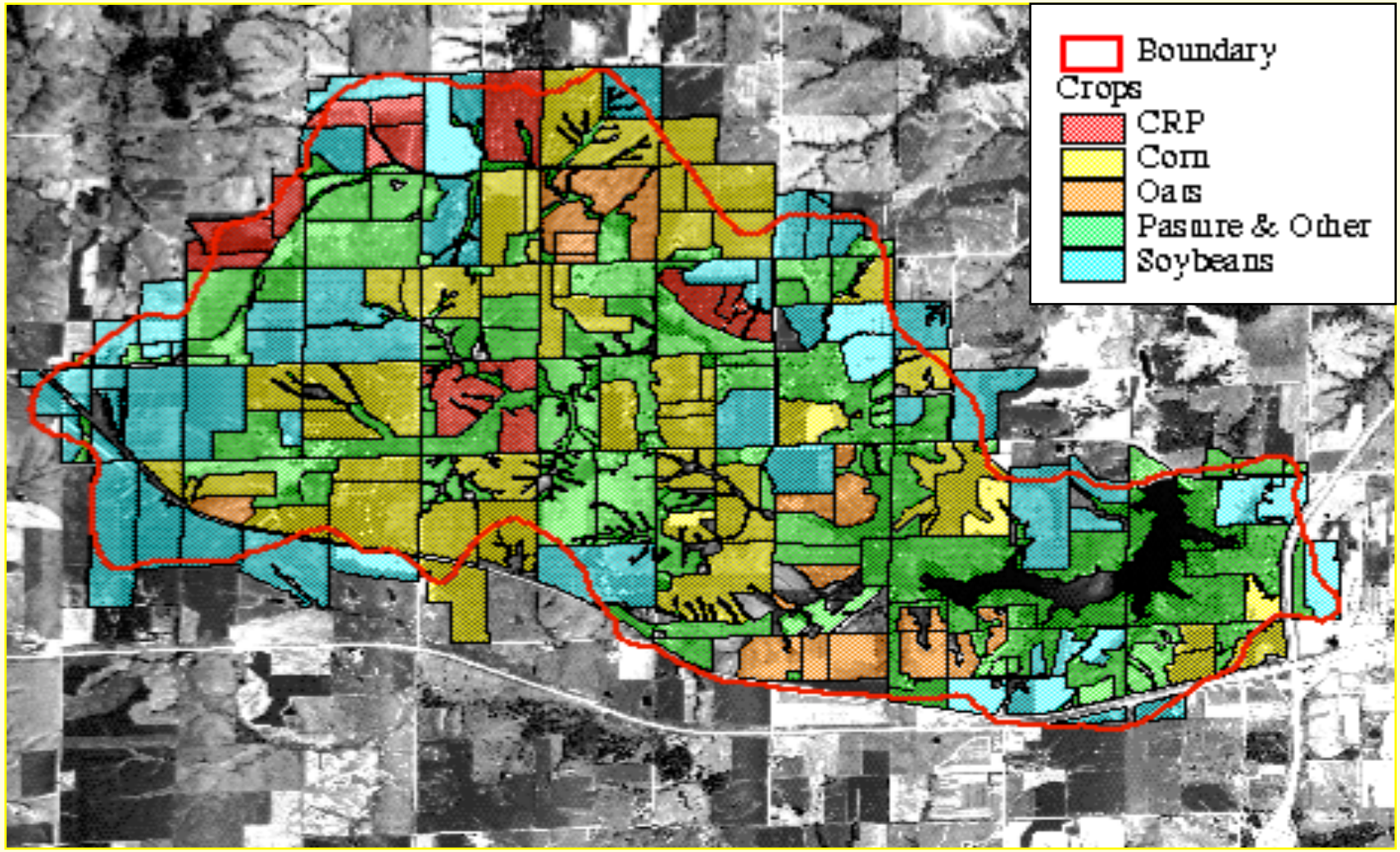
Classification

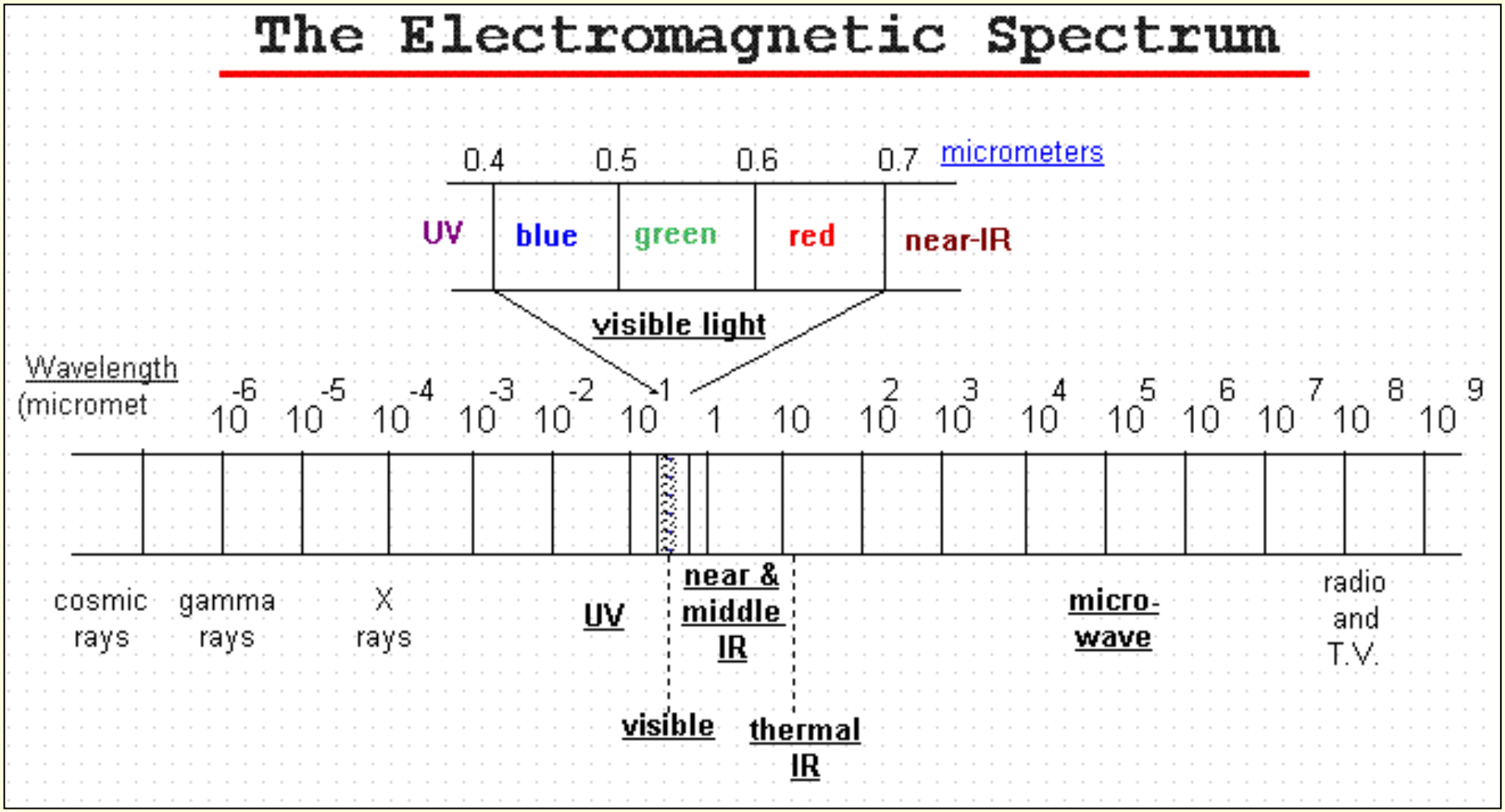


Crop Classification

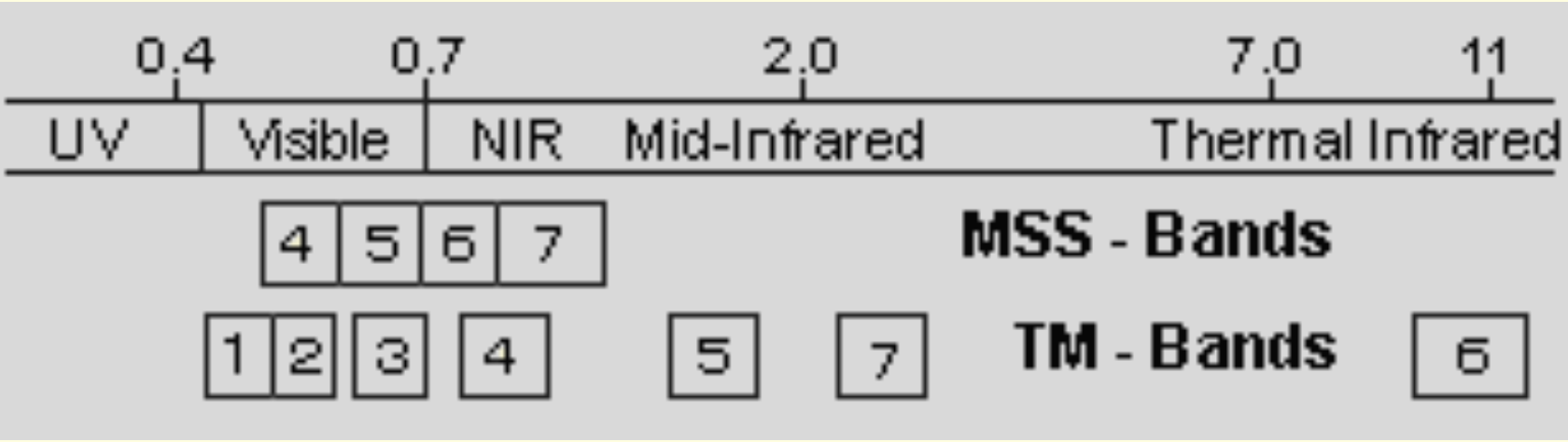
Classification

- Key remote sensing processing technique
- Placing pixels into thematic categories that correspond to land cover types
  - e.g. forest, crops, water, urban, etc.
- Basis for classification are the spectral signatures of landcover types

The Electromagnetic Spectrum

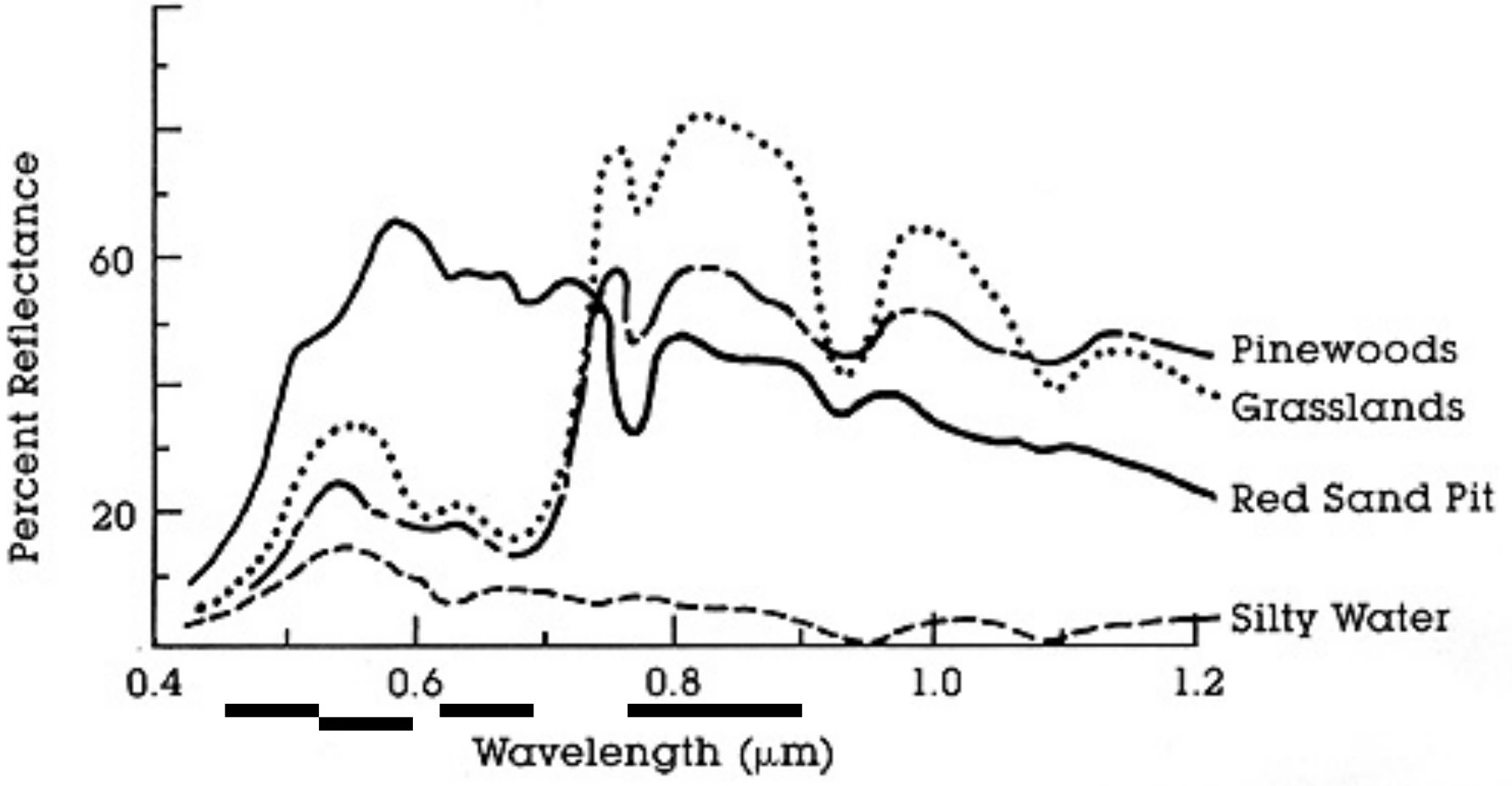


Landsat TM Bands



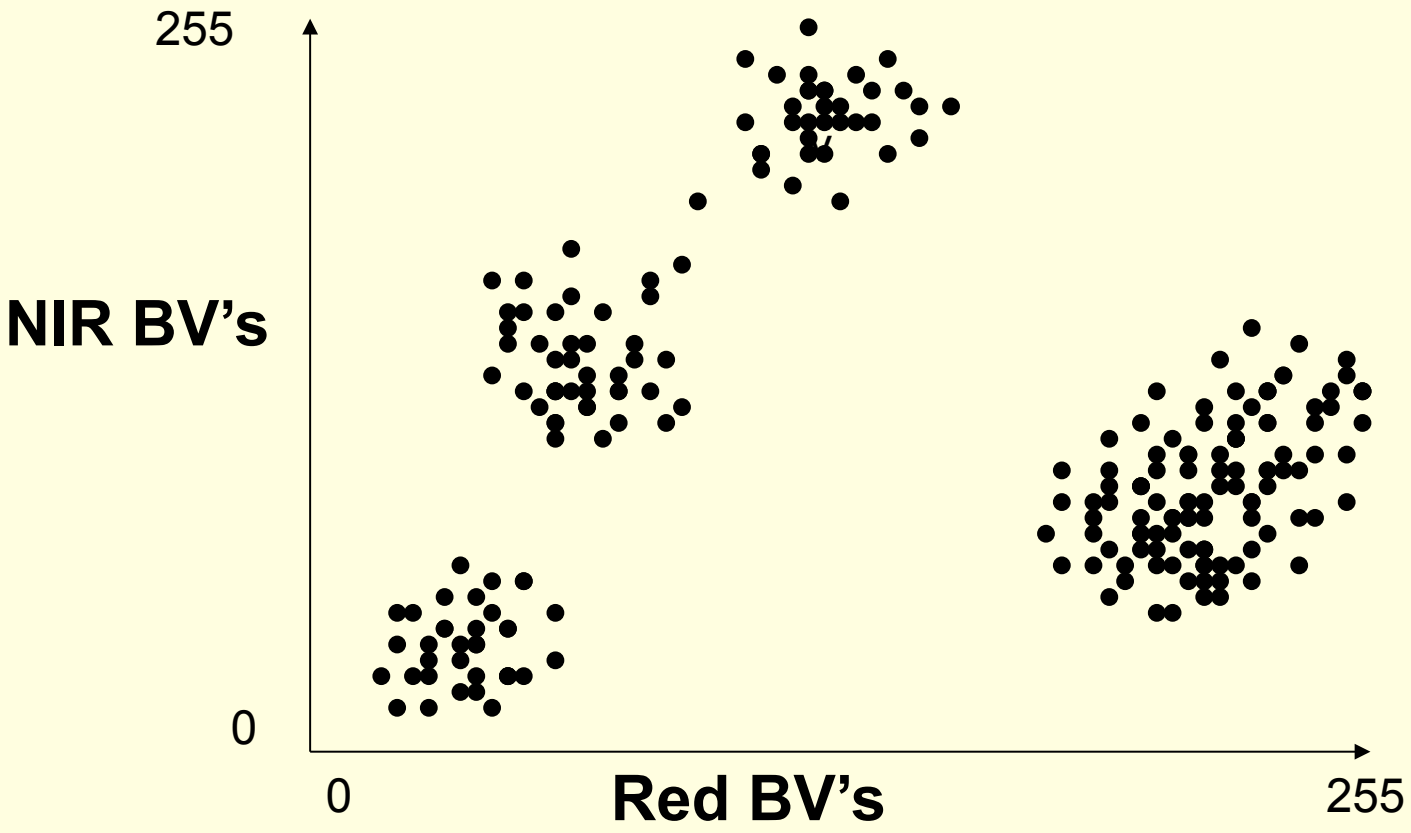
Spectral Resolution of Landsat TM

These bands provide a coarse summary of spectral signatures.



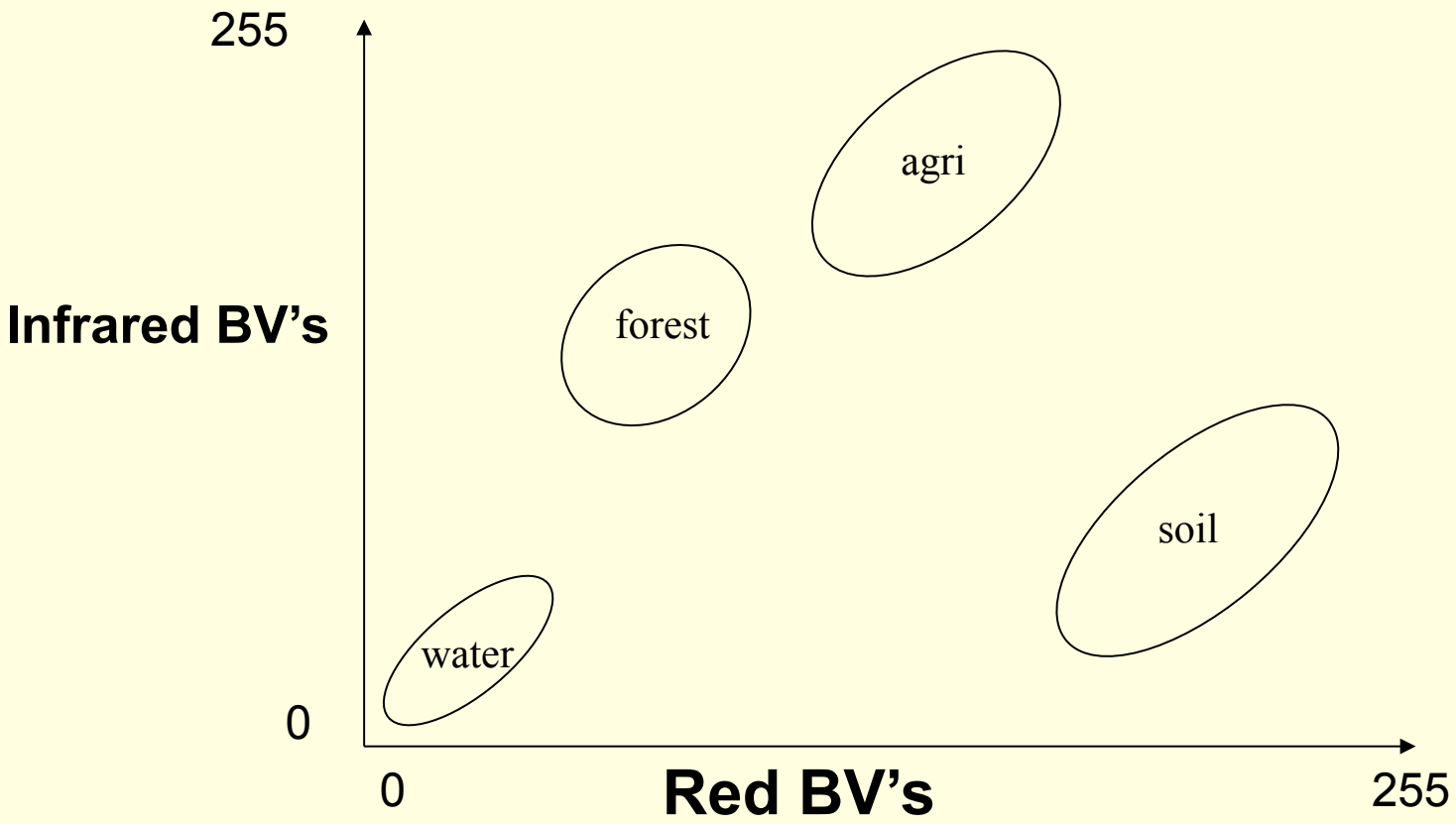
TM Band: 1 2 3 4(NIR) 5(MIR)

Feature Space
(2 bands)



Feature Space

Pixels in the same classes cluster

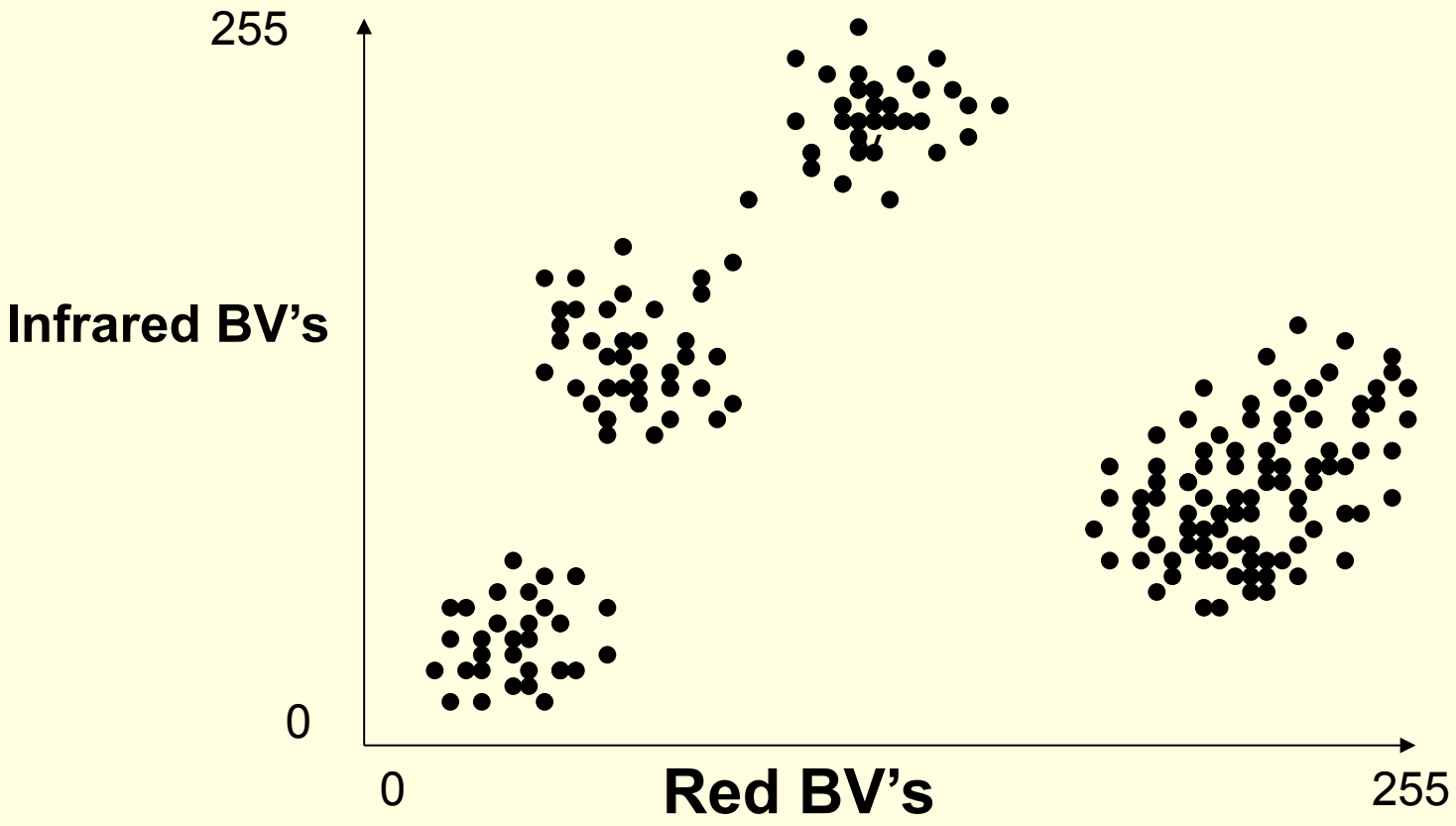


Classification

- Two essential types of classification
  - Unsupervised
    - Unsupervised by humans
    - Computer algorithm-based
  - Supervised
    - Supervised by human(s)
    - Human-trained
    - Algorithms also used

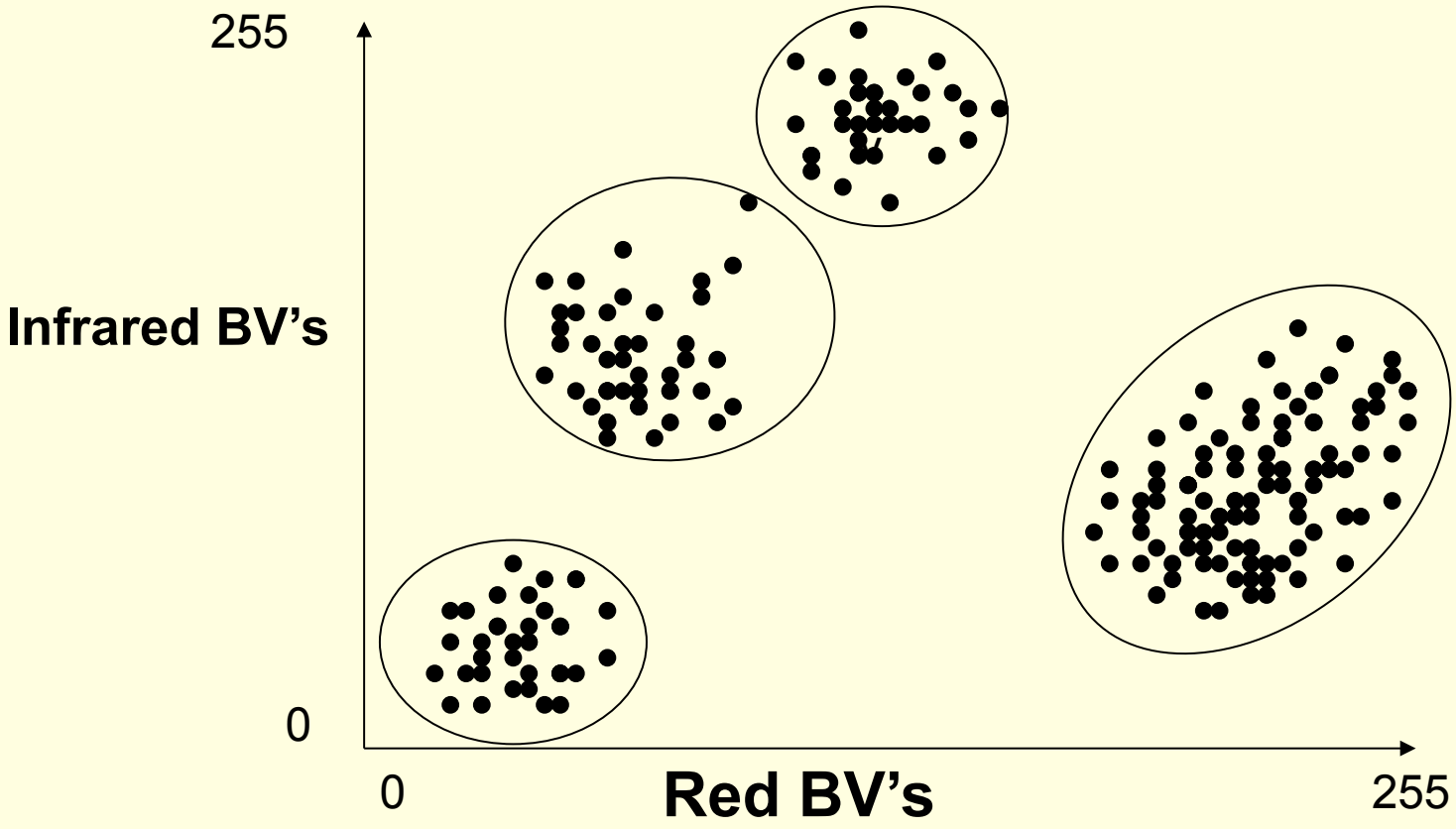
Unsupervised Classification

- Classes are created based on the locations in feature space of the pixel data



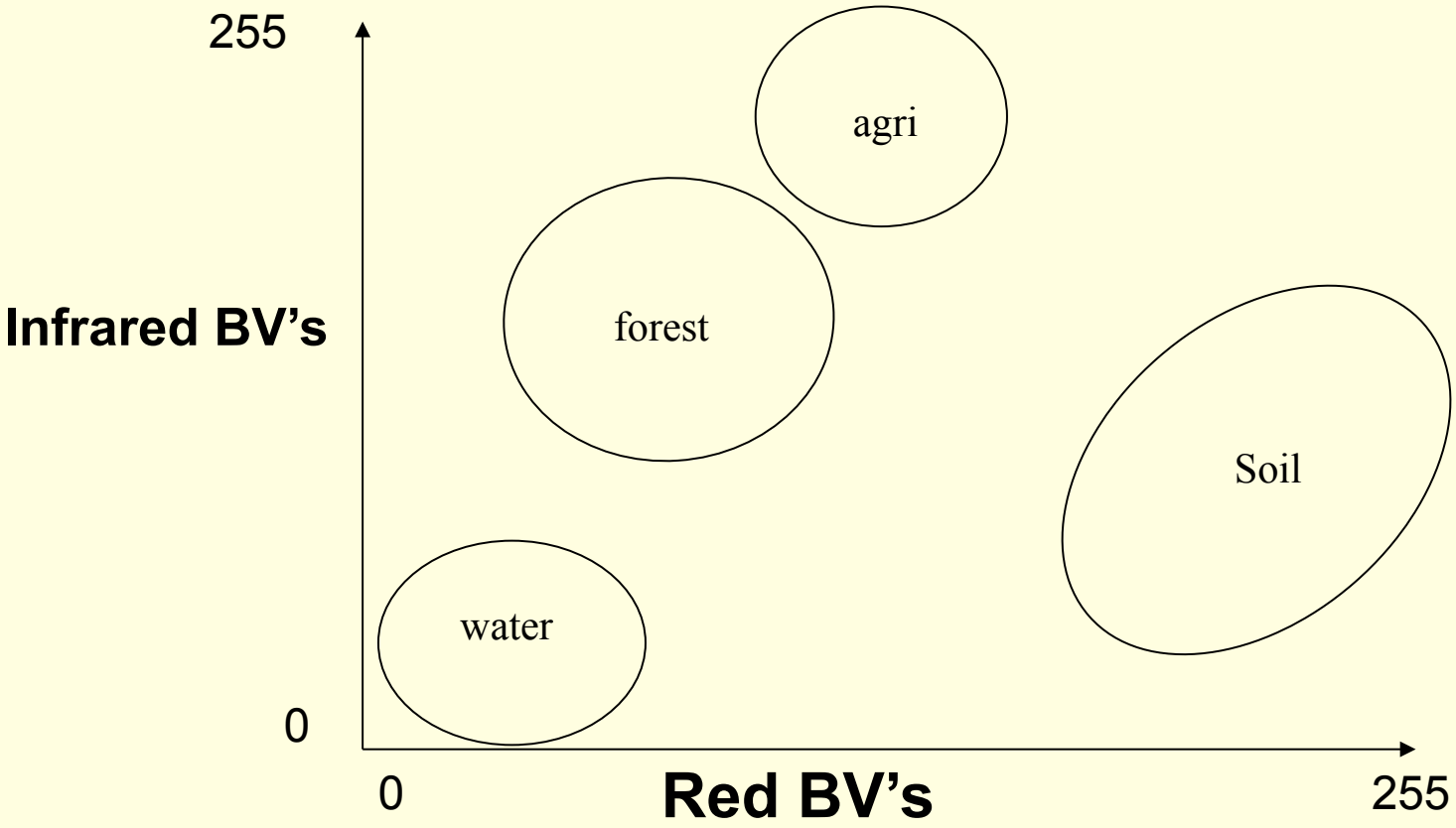
Unsupervised Classification

Computer Algorithm Finds Clusters

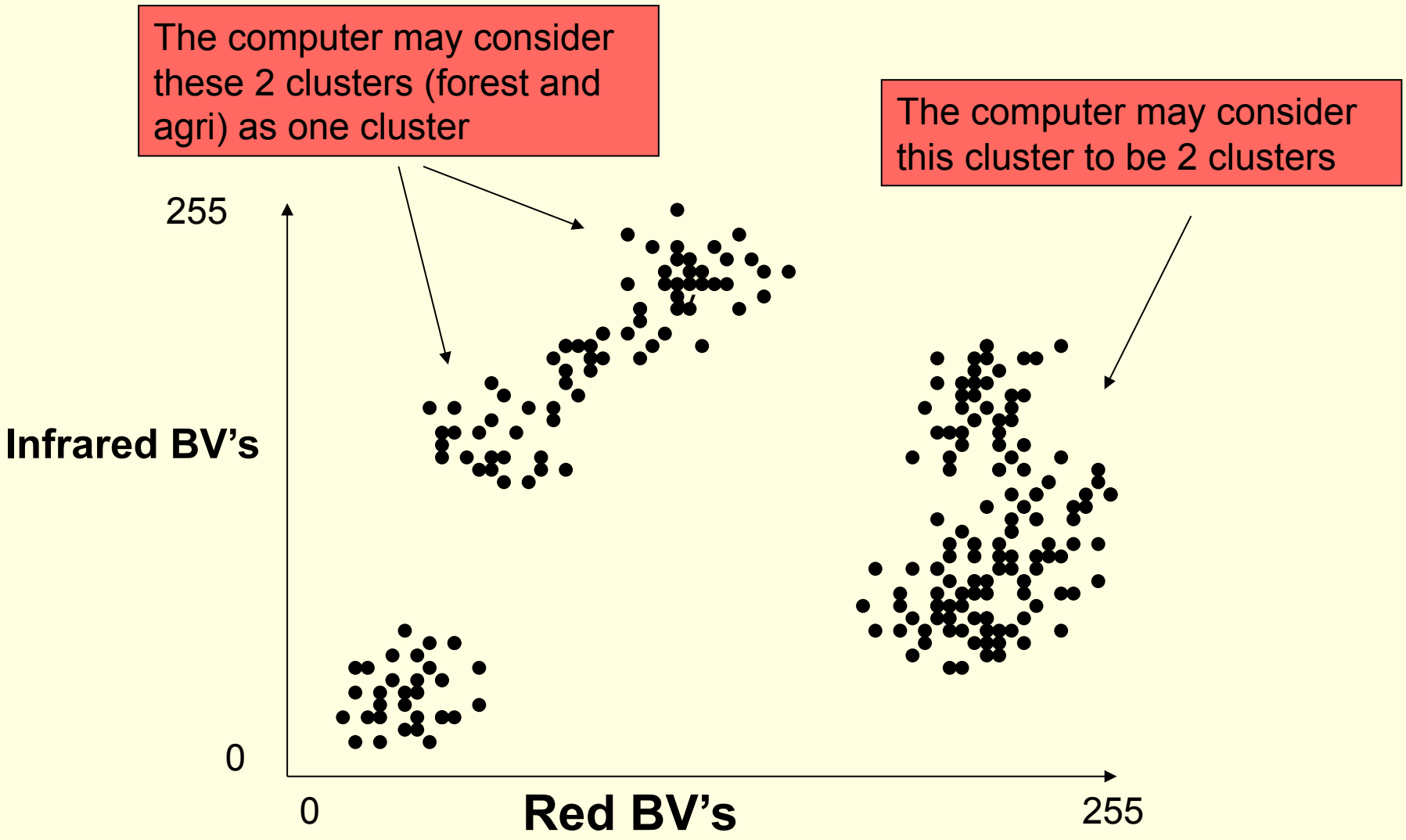


Unsupervised Classification

- Attribution phase – performed by human



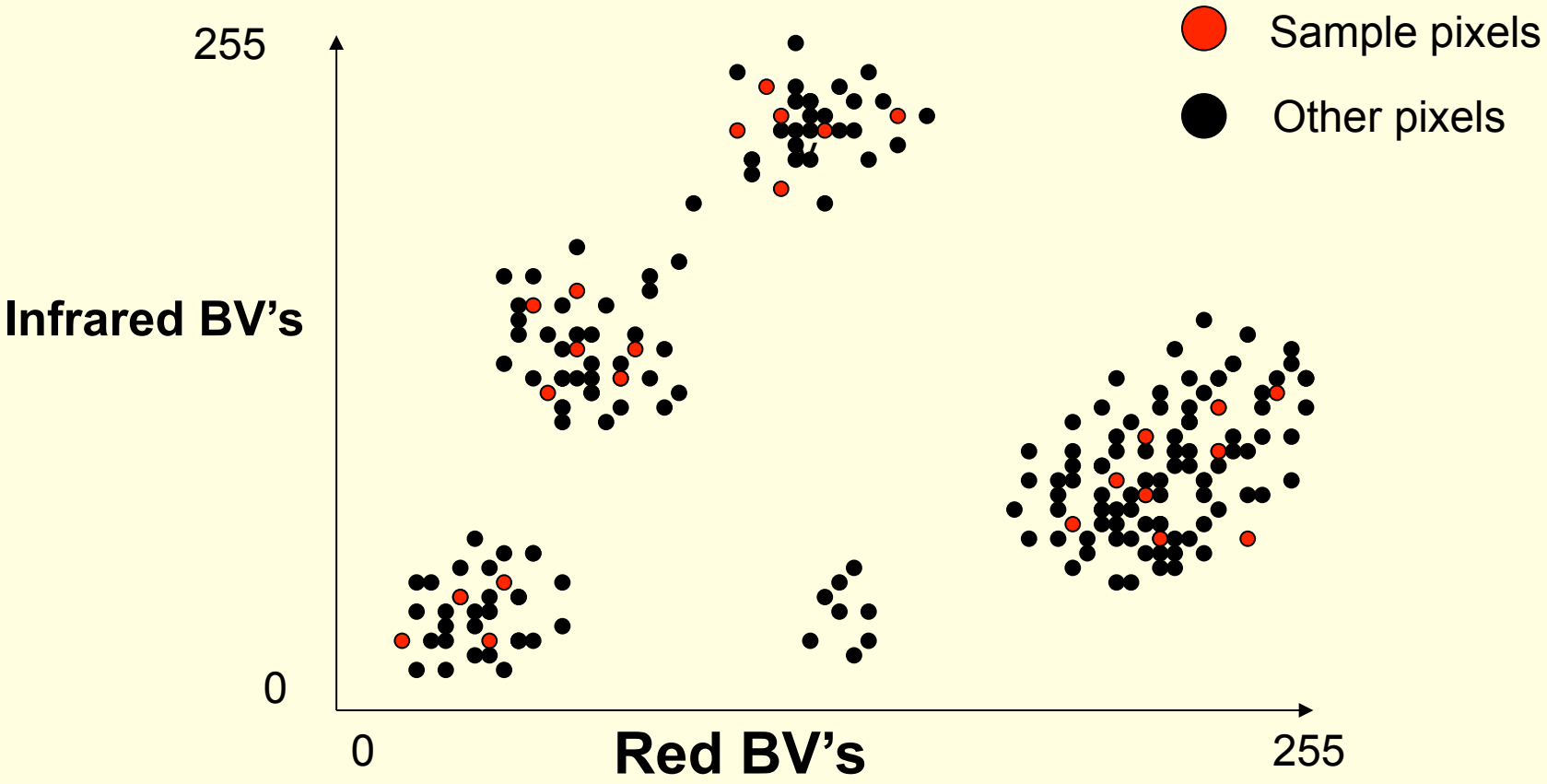
Problems with Unsupervised Classification



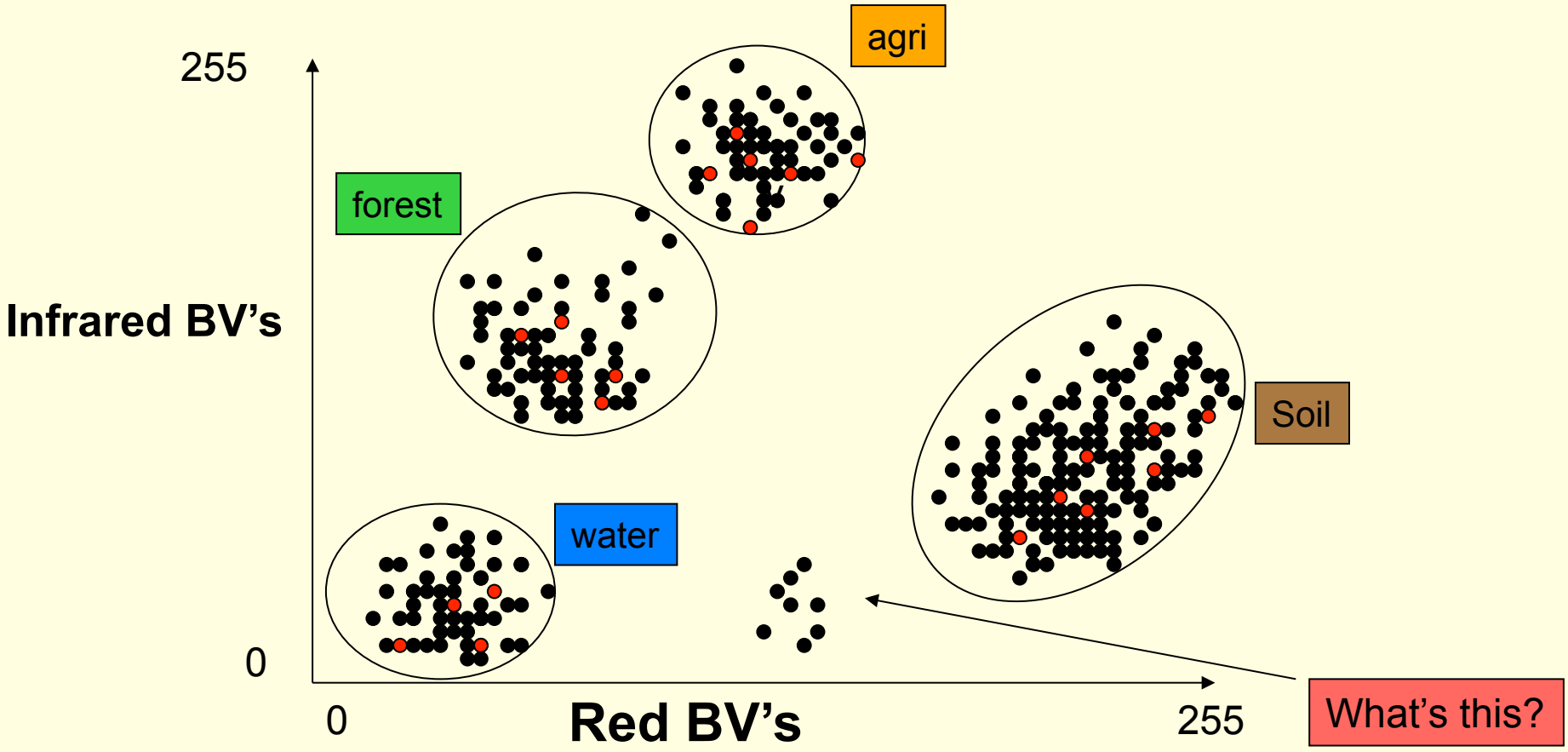
Supervised Classfication

- We “train” the computer program using ground truth data

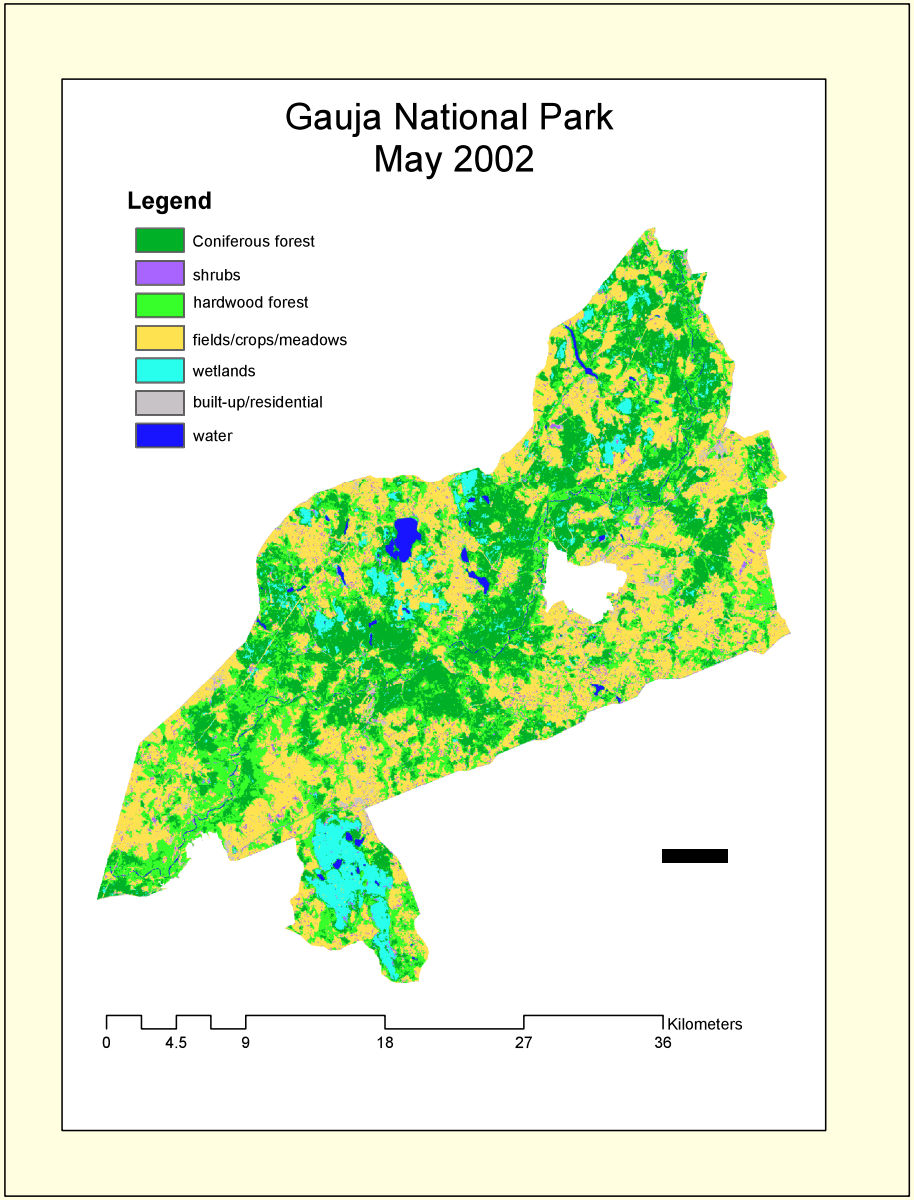
Supervised Classification



Problems with Supervised Classification



The Result: A Classified Image



Classification scheme

(important for both supervised and unsupervised classifications)

- **Classification scheme**: the set of classes used to classify an image
  - Classes chosen to be appropriate for use of data
  - Sufficient number of classes chosen
    - Don't want pixels that don't resemble any samples (how would we classify these?)
  - Good to use or adapt standard classification schemes
    - Helpful to compare your analysis with other analyses
    - Standard hierarchical schemes exist, and you can choose the level of detail appropriate for your goals
      - Common classification systems used in Europe:
        - » CORINE (Coordination of Information on the Environment)
        - » LCCS (Land Cover Classification System)

Key advantages of supervised classification (relative to unsupervised)

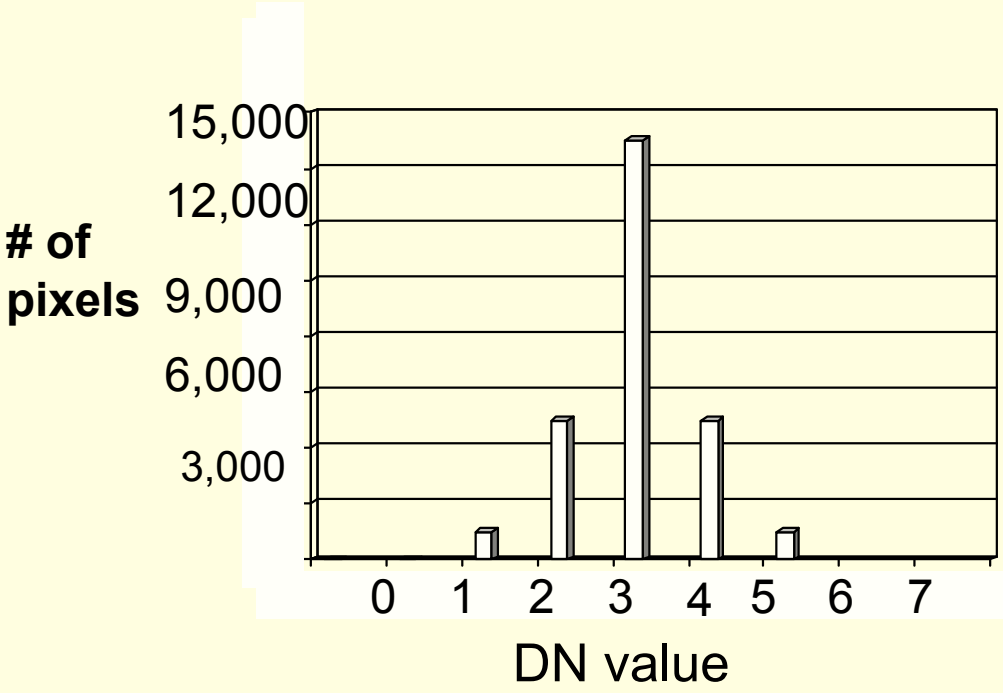
- Images using supervised classification are more easily comparable to other images (of different dates or neighboring regions).
- Class definitions are based on data about training samples of known landcover type.
  - Potential for higher accuracy
- Avoids the difficult attribution stage of unsupervised classification.

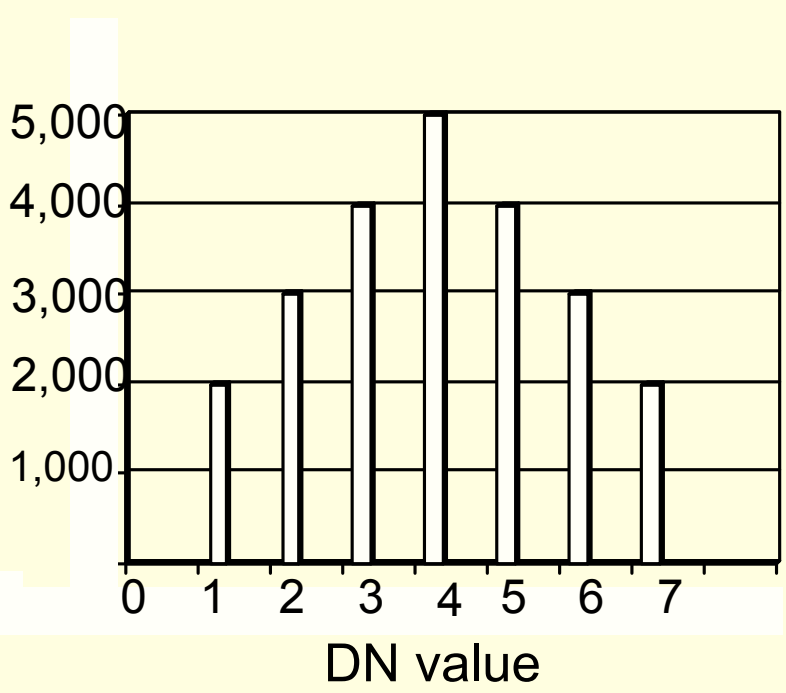
Key disadvantages of supervised classification (relative to unsupervised)

- Supervised classification assigns pixels to one of the user-defined classes. Some pixels may represent a landcover type that doesn't fit one of those classes.
- One class may have a highly variable signature (possibly bimodal or 'multimodal')
  - this can hinder the classification process.
- Getting good, representative training data is important but may not be possible.
- Process is substantially slower & more expensive than unsupervised.

Break for statistics brief

Concept of Variance

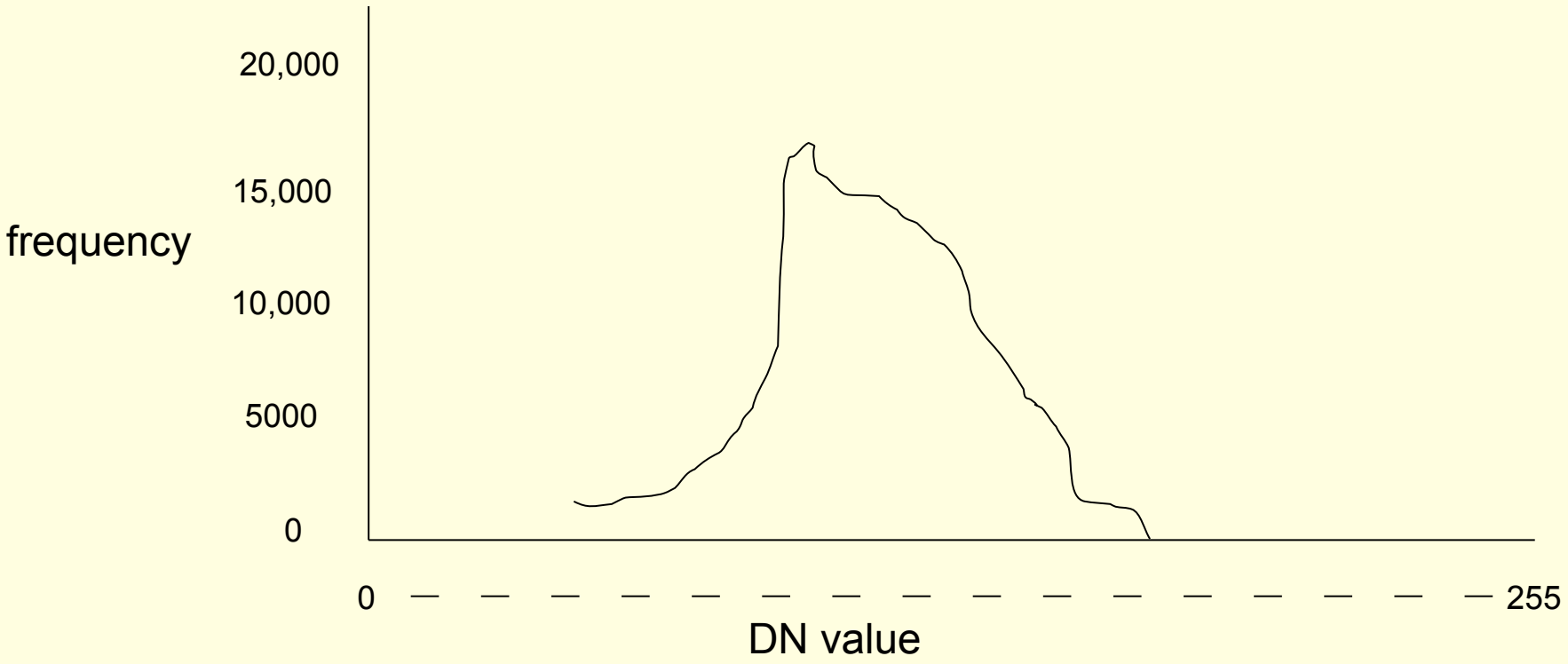




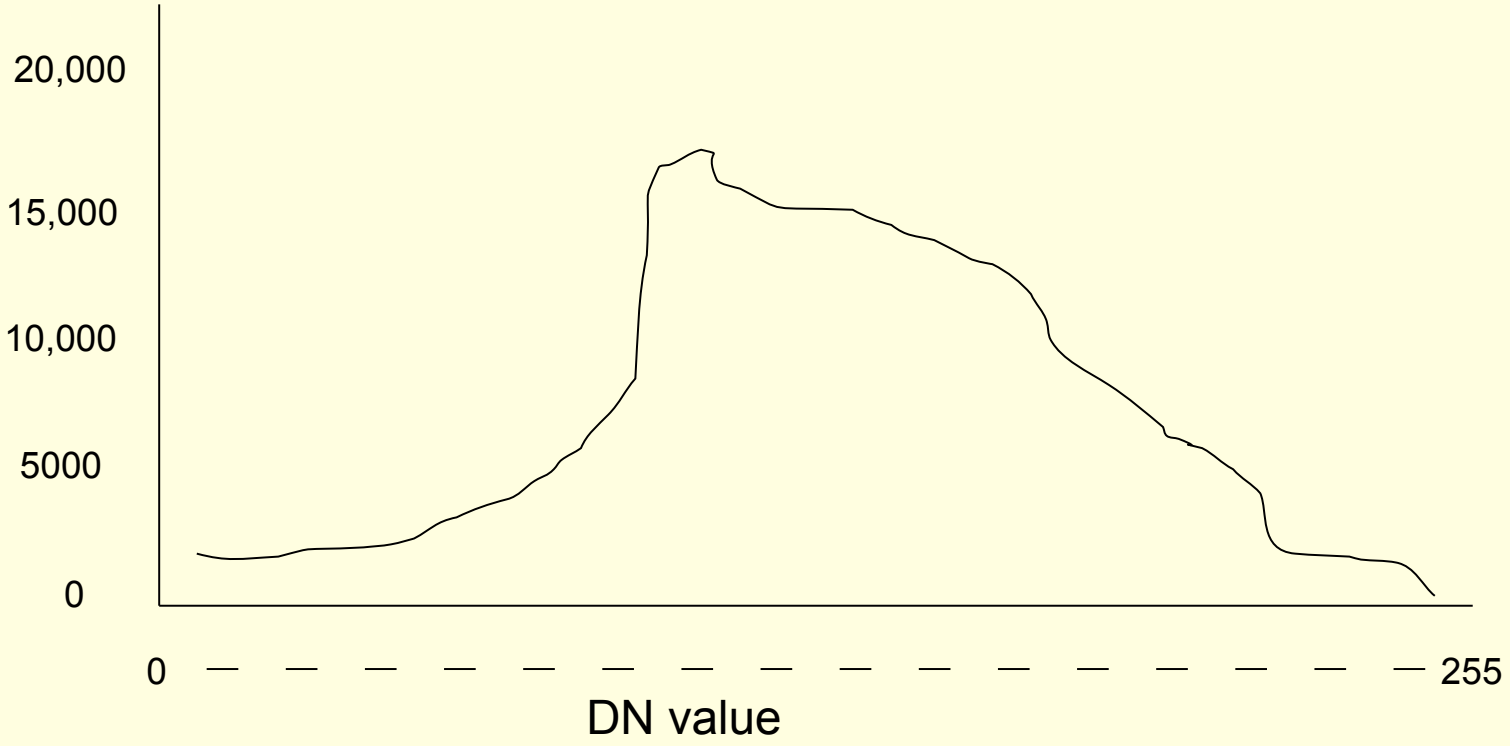
Low variance

High variance

A Distribution



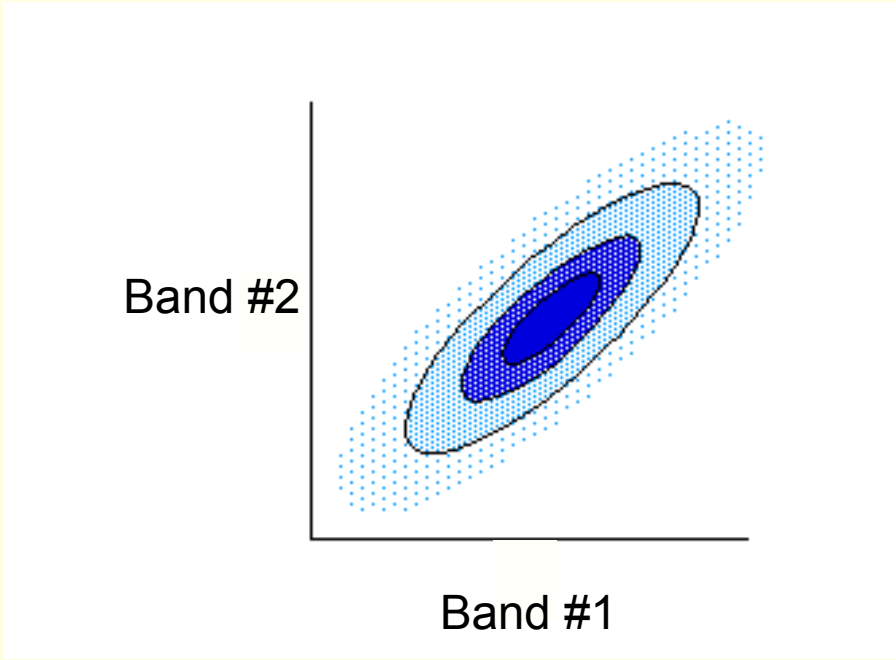
Another Distribution



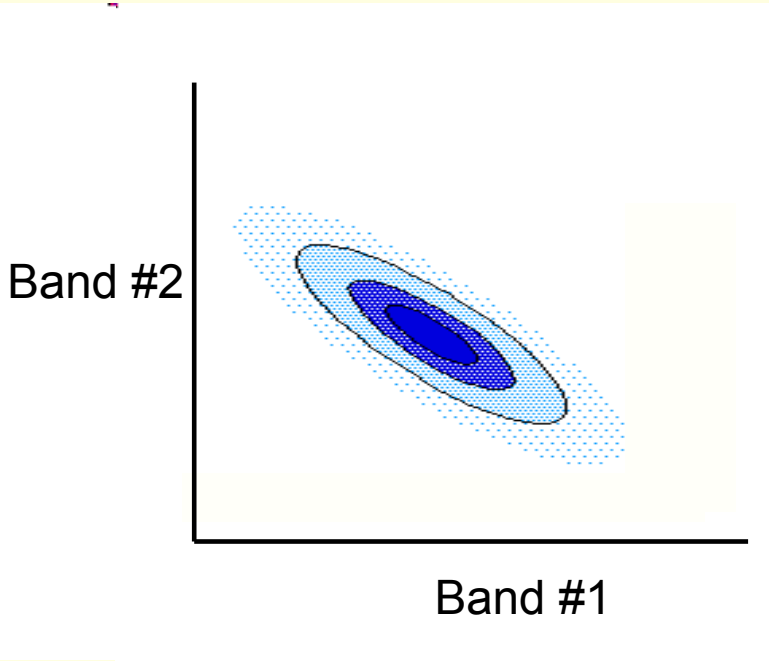
Does this distribution have more or less variance than the one on the previous slide?

Variance – covariance

In addition to variances for each band, a *covariance* is calculated which measures how one band tends to vary with the other band.



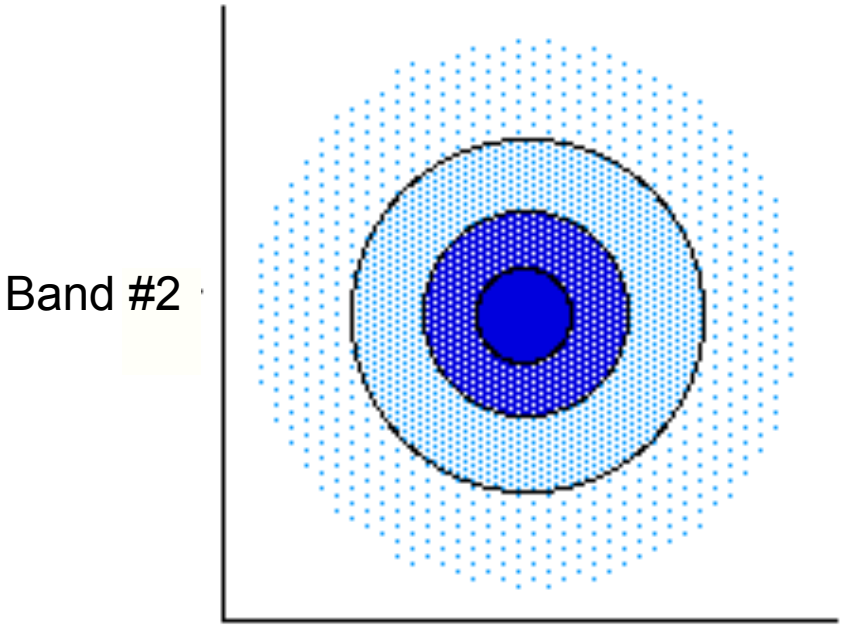
Positive covariance



Negative covariance

Bivariate distribution

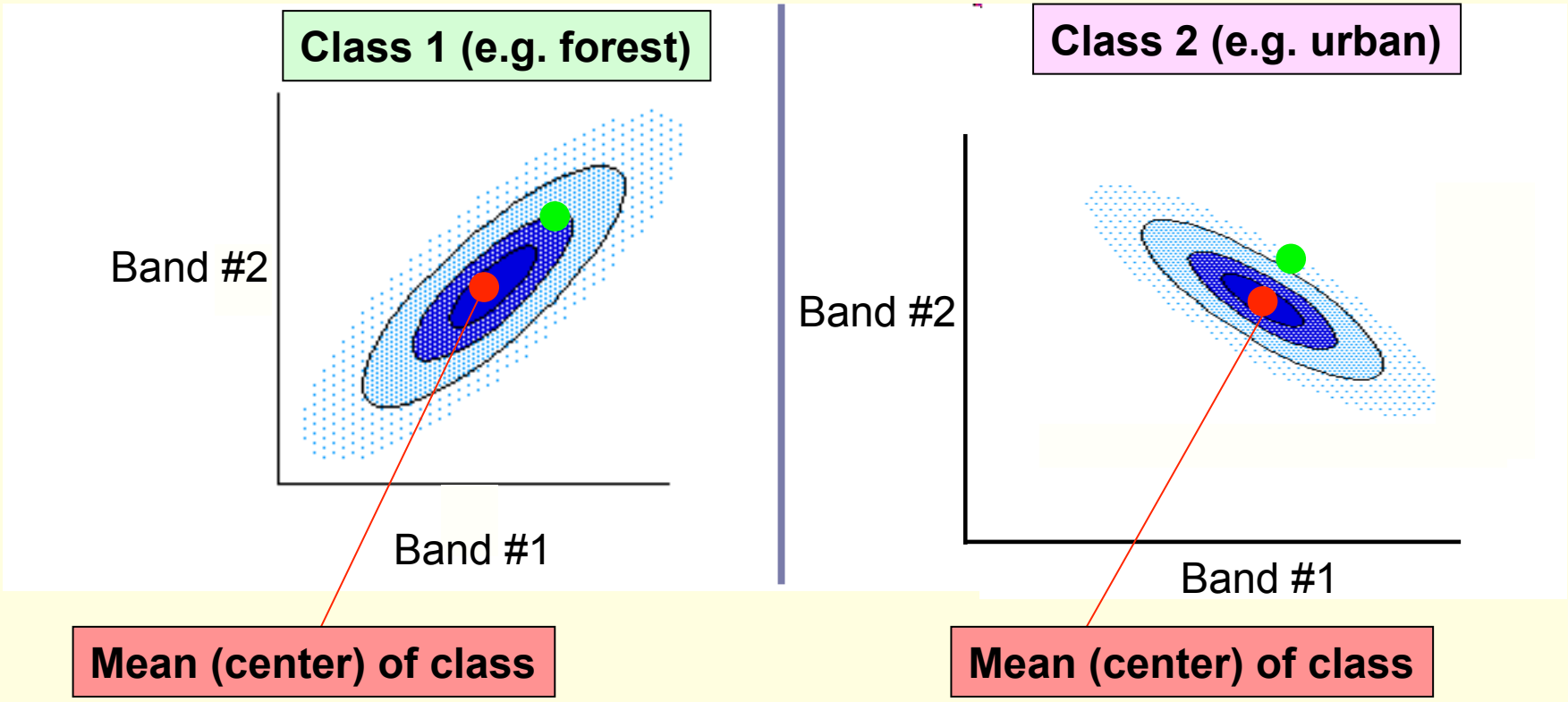
Another look



Zero covariance

Distances

Distances can be calculated in terms of variances and covariances for each class.



The concentric ellipses are densities of points. The more "rings" out from the center a point is, the farther away it is from the center in terms of the variance-covariance of that class.

In terms of variance-covariance, for which class is the green dot near to the mean of that class?

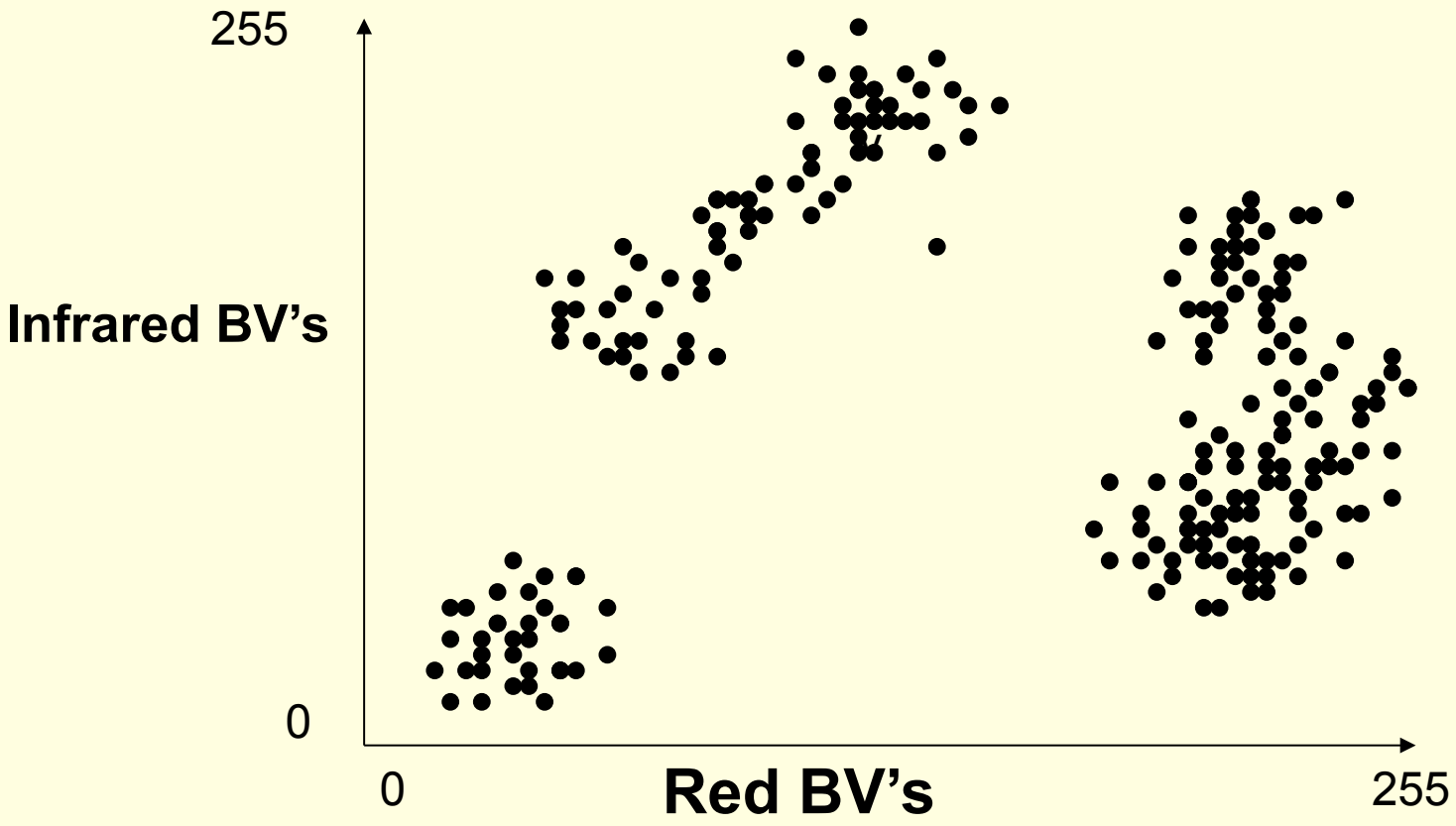
Back to remote sensing: ISODATA method of Unsupervised Classification

The most commonly used unsupervised method.

ISODATA Algorithm

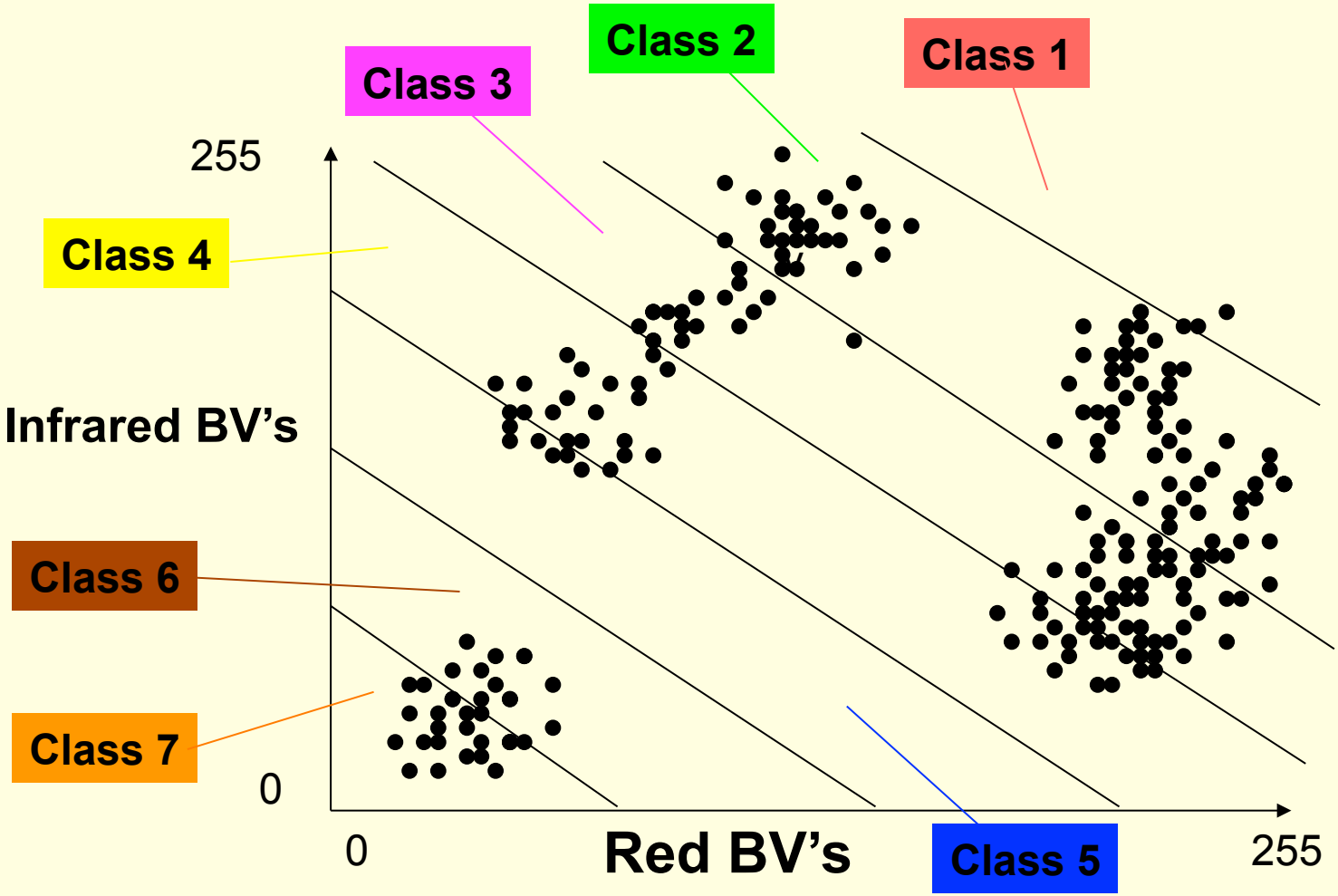
Assume these are the data of a satellite image to be classified.

Here we only use 2 bands of data, but the process can be generalized for any number of bands.



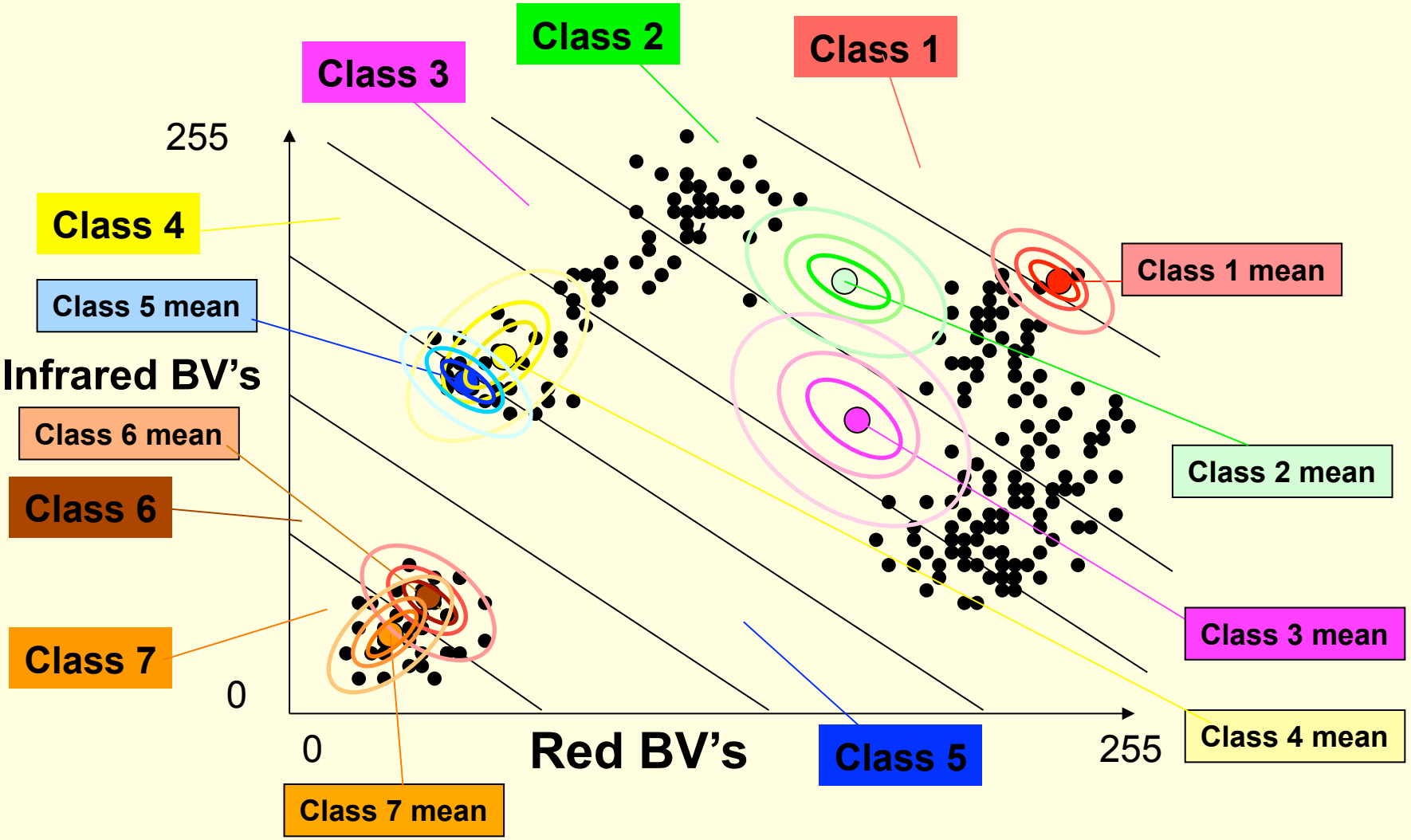
ISODATA Algorithm

Step 1: ISODATA algorithm creates arbitrary classes to "seed" the process



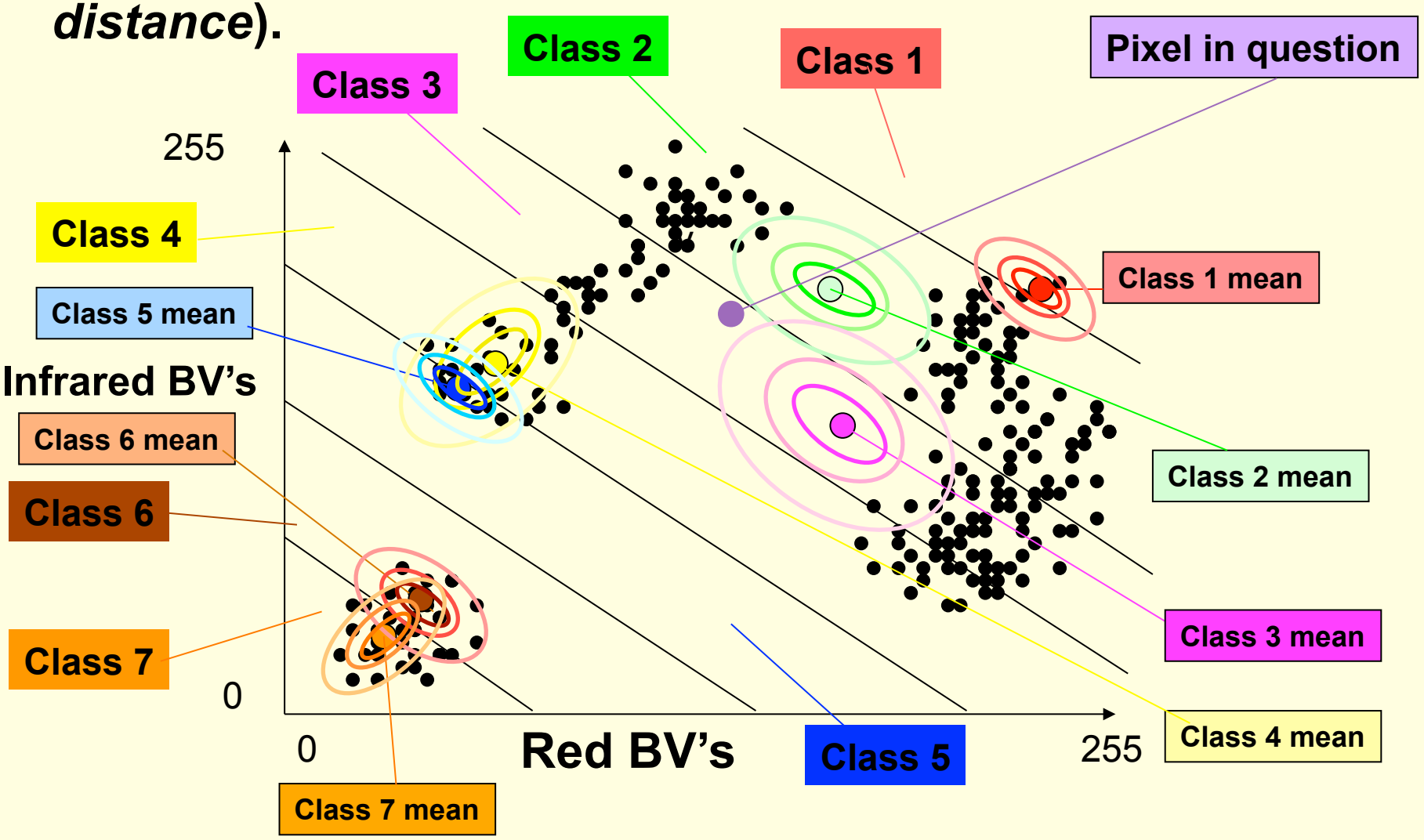
ISODATA Algorithm

Step 2: ISODATA algorithm calculates the mean, variance, and covariance of the data within each class.



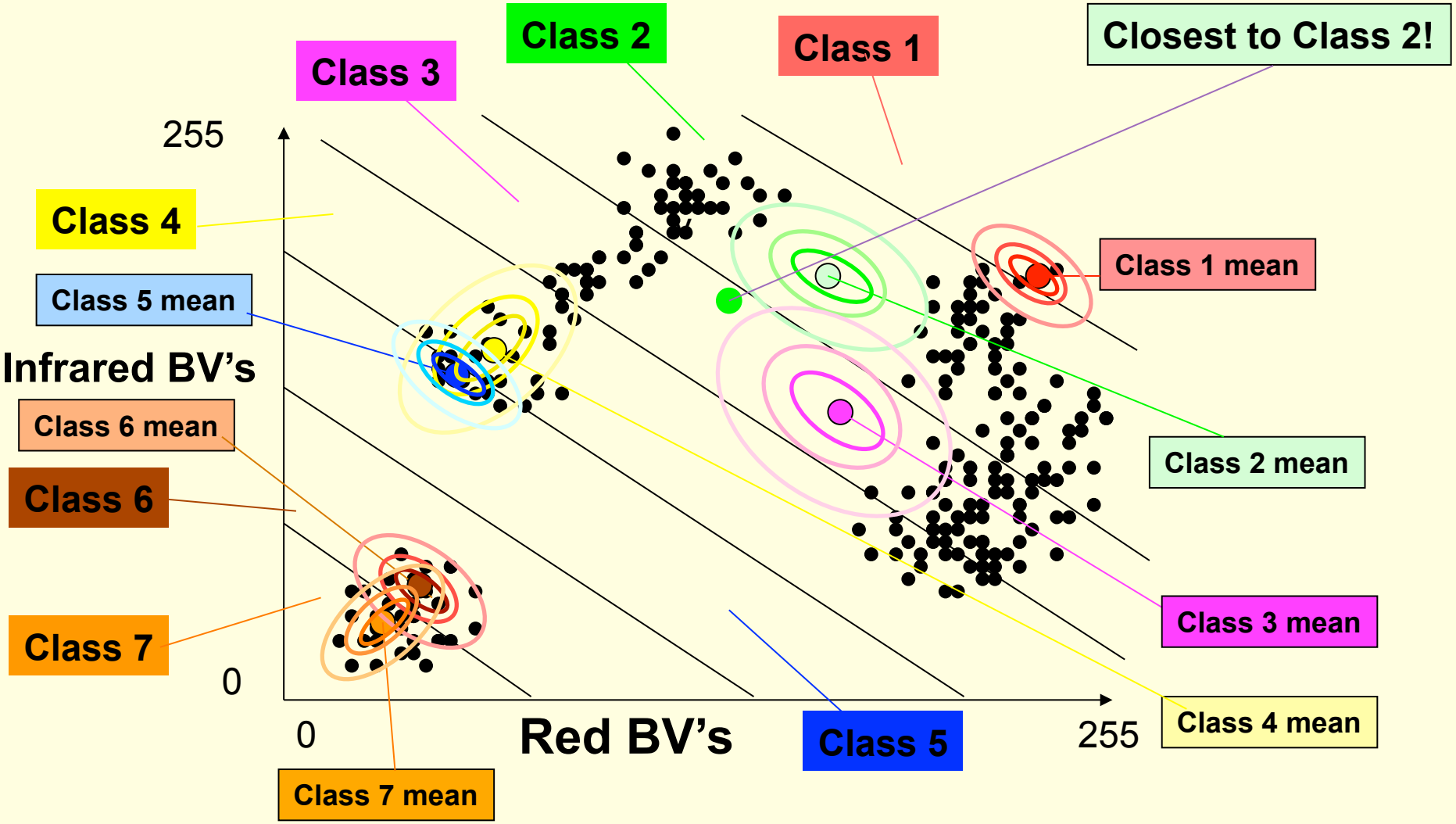
ISODATA Algorithm

Step 3: ISODATA algorithm finds the nearest class mean to each pixel (in terms of *variance-covariance distance*).



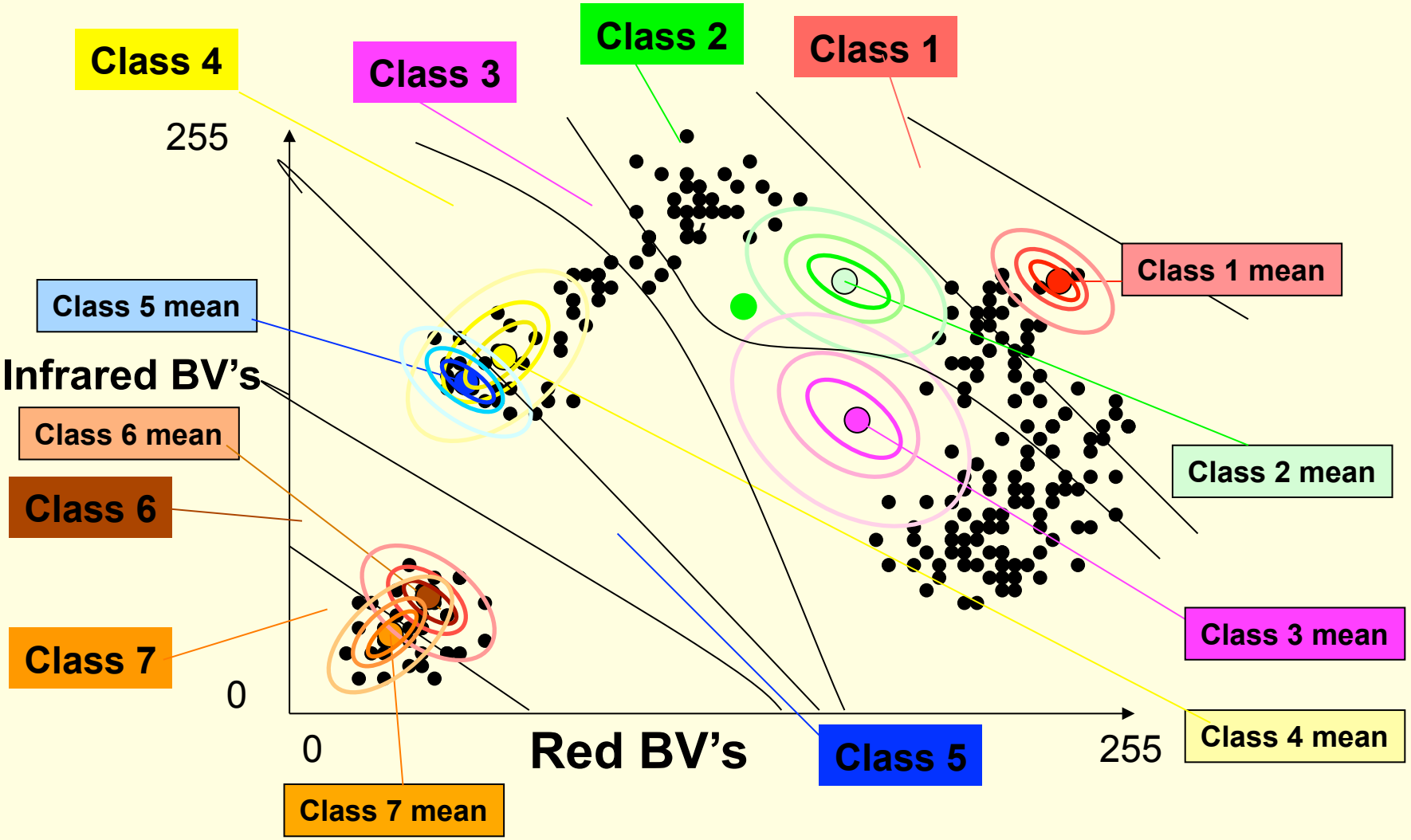
ISODATA Algorithm

Step 4: ISODATA algorithm reallocates each pixel to its new class, based on which class mean it's nearest to.



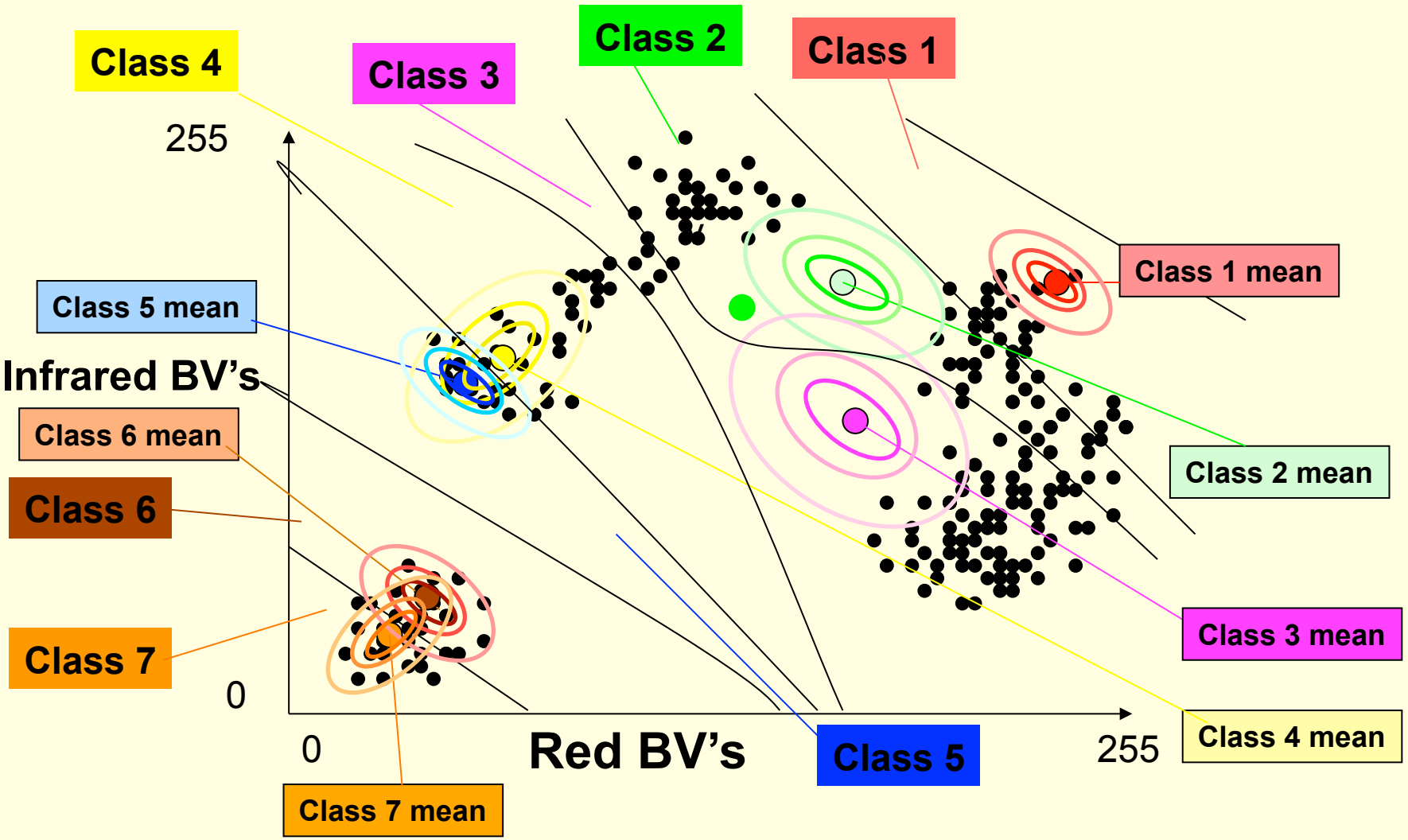
ISODATA Algorithm

Step 5: ISODATA algorithm re-draws the class boundaries to accommodate the new class assignments.



ISODATA Algorithm

Go back to Step 2: ISODATA algorithm calculates the mean, variance, and covariance of the data within each new class.



ISODATA Algorithm

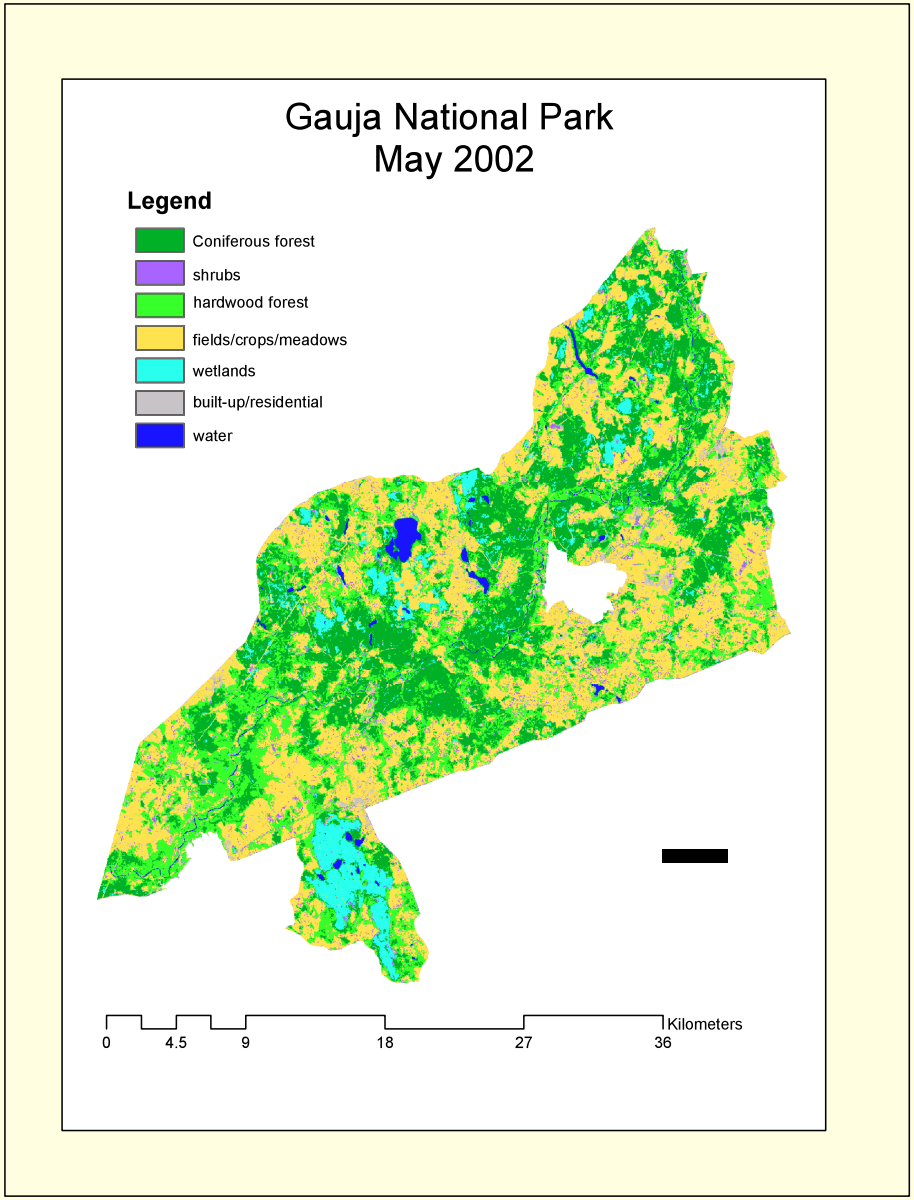
This iterative process continues until either:

1. A predefined number of iterations finish, or
2. the proportion of pixels that change classes between iterations becomes less than a predefined threshold.

Result of unsupervised classification

- A map with each pixel assigned to a particular (numbered) class.
- Next step: attribution
  - A particular landcover category is determined and assigned to each numbered class.
  - Usually done by the analyst.

Final Result: A Classified Image

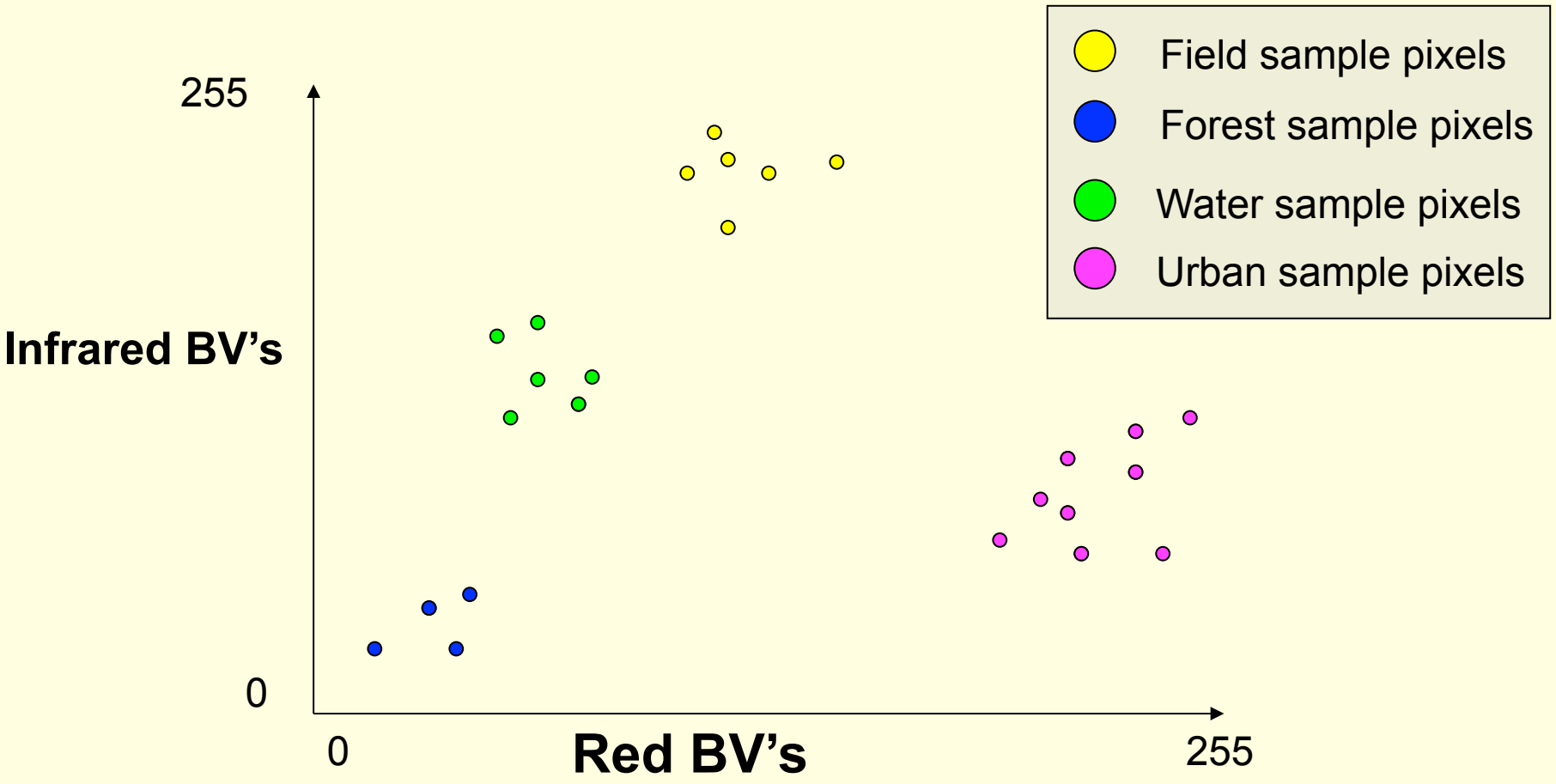


Supervised classification

- Parallelepiped method
- Maximum likelihood method

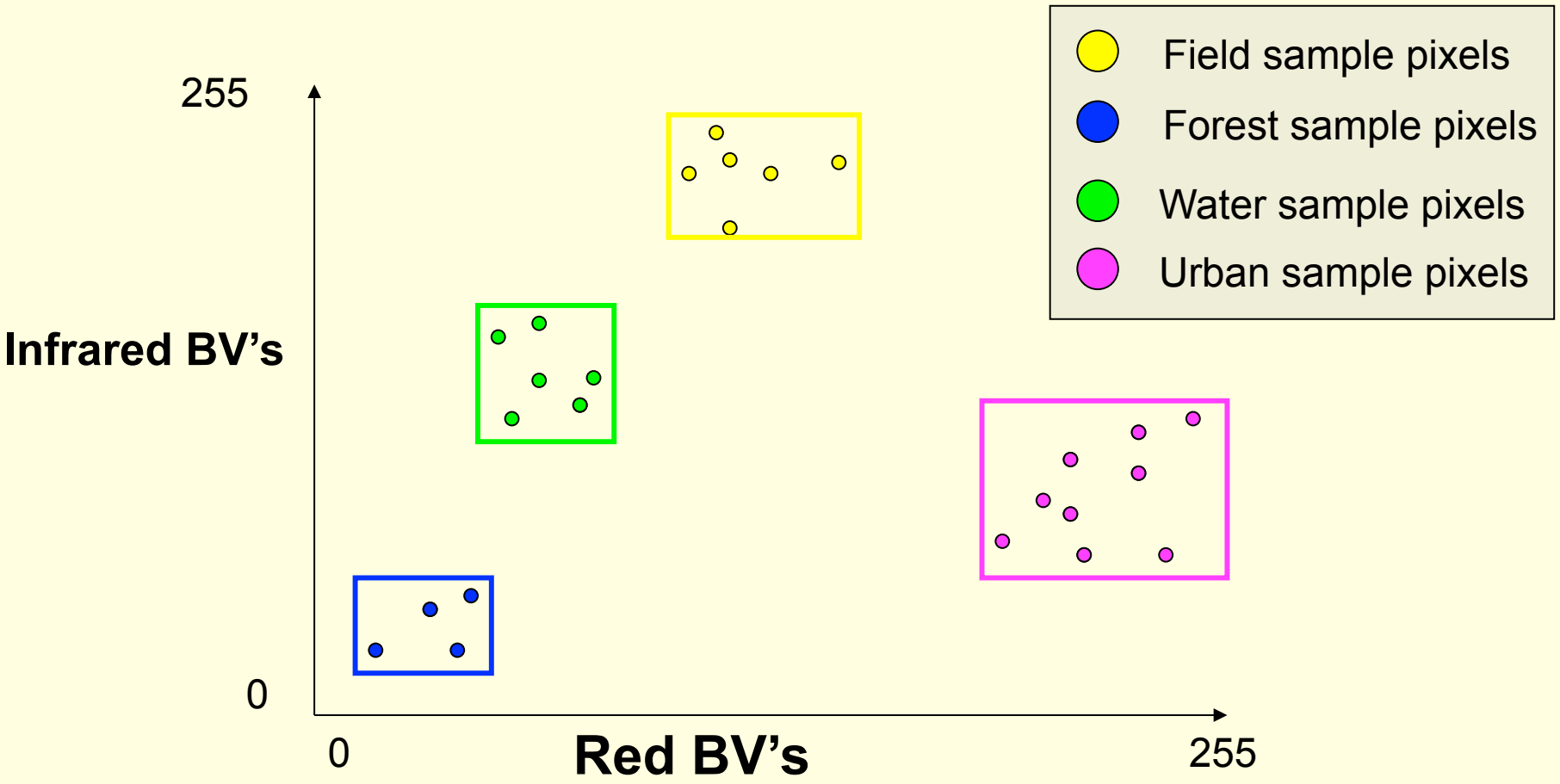
Parellepiped Method

Sample pixels are plotted in spectral space using a subset of bands (in this case, 2 bands, so the plot is 2-dimensional).



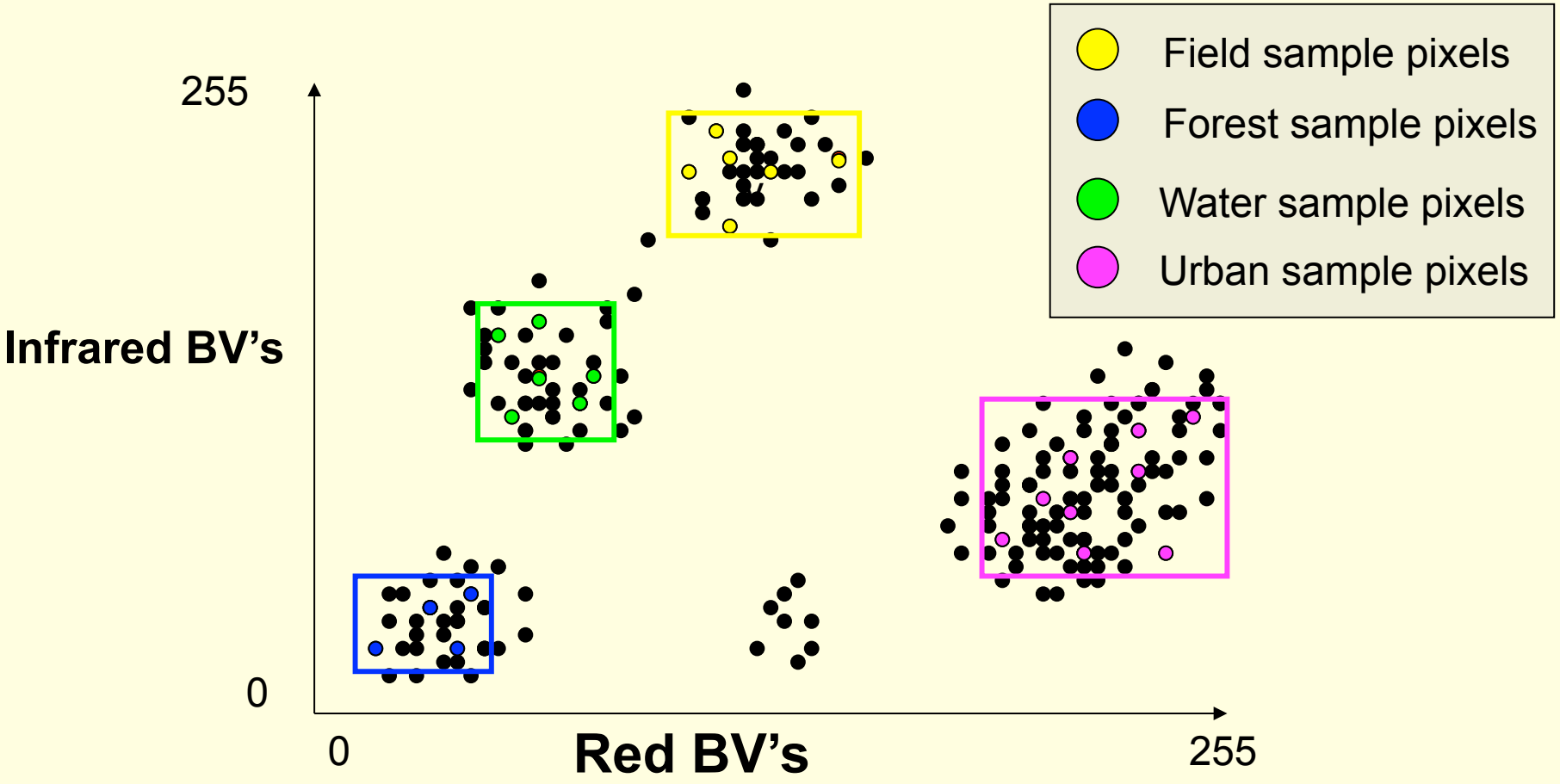
Parellepiped Method

Boxes (parallelepipeds) are drawn around the sample pixles of each class.



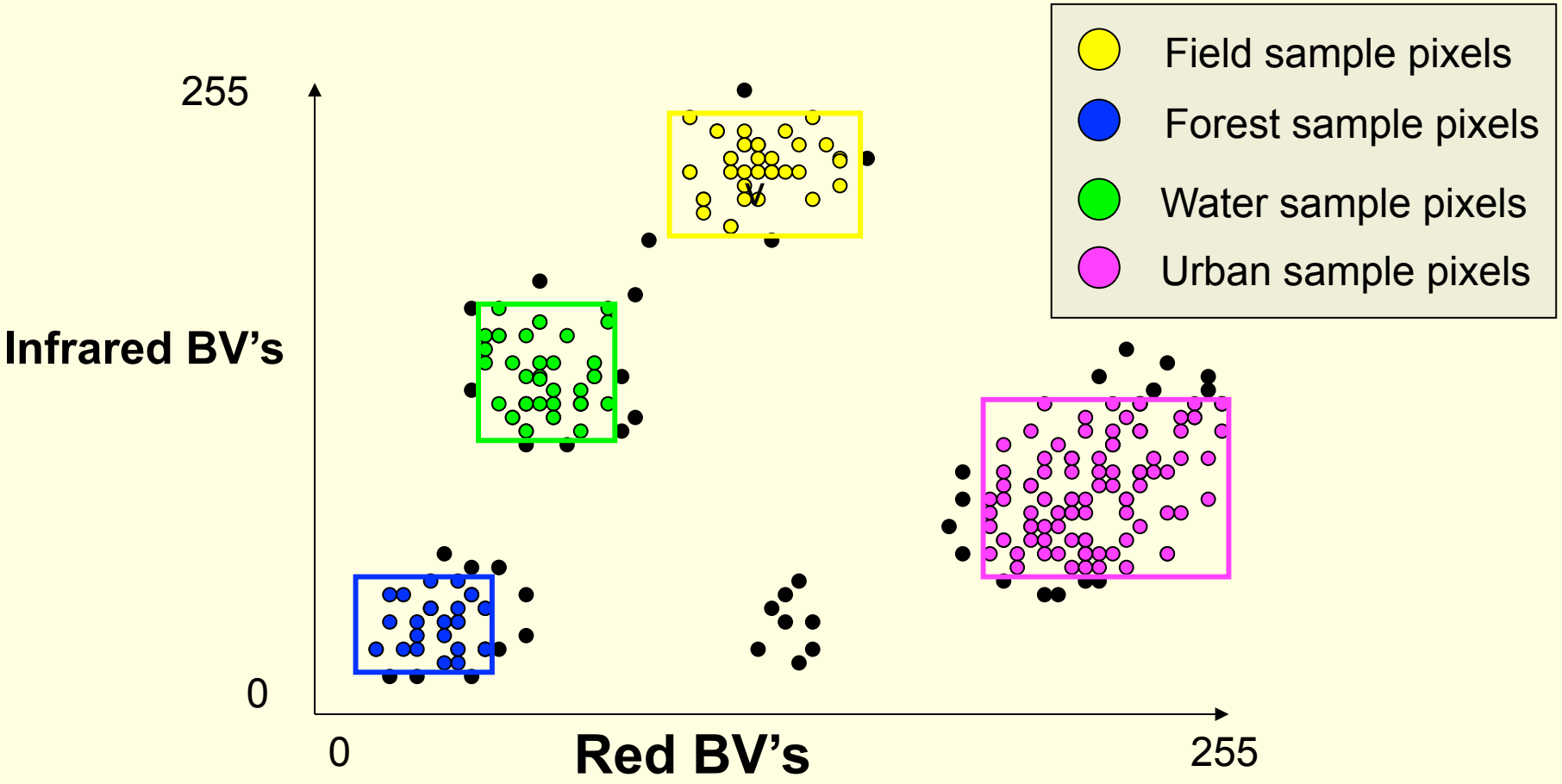
Parellepiped Method

Then the full dataset is plotted in this spectral space with the parallelepipeds (all pixels – not just sample pixels).



Parellepiped Method

All of the image pixels that fall within each parallelepiped are classified as the same class as the sample pixels within that parallelepiped.



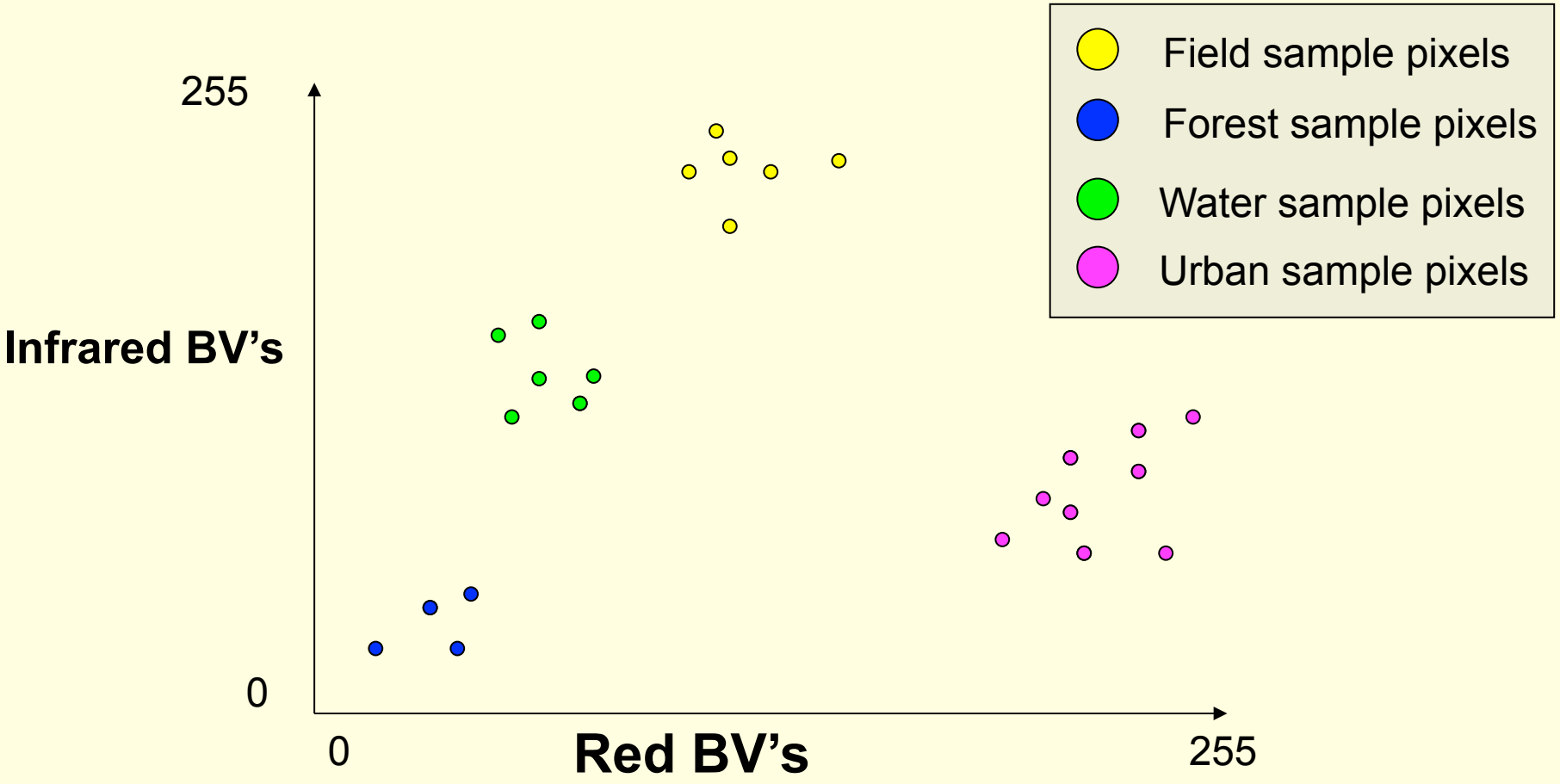
Note: parallelepipeds can be "drawn" in more than 3 dimensions to incorporate as many bands of data as desired.

Parallelepiped Method

- One of the first methods developed for supervised classification
- Intuitive
- Leaves some pixels unclassified
- Other methods are more accurate
- A variation on this method is still often used:
  - Instead of the computer algorithm drawing the parallelepipeds, an analyst can draw them
  - Shapes can be of any kind (not confined to parallelepipeds)
  - This can be a good, highly accurate method to classify some or all of an image

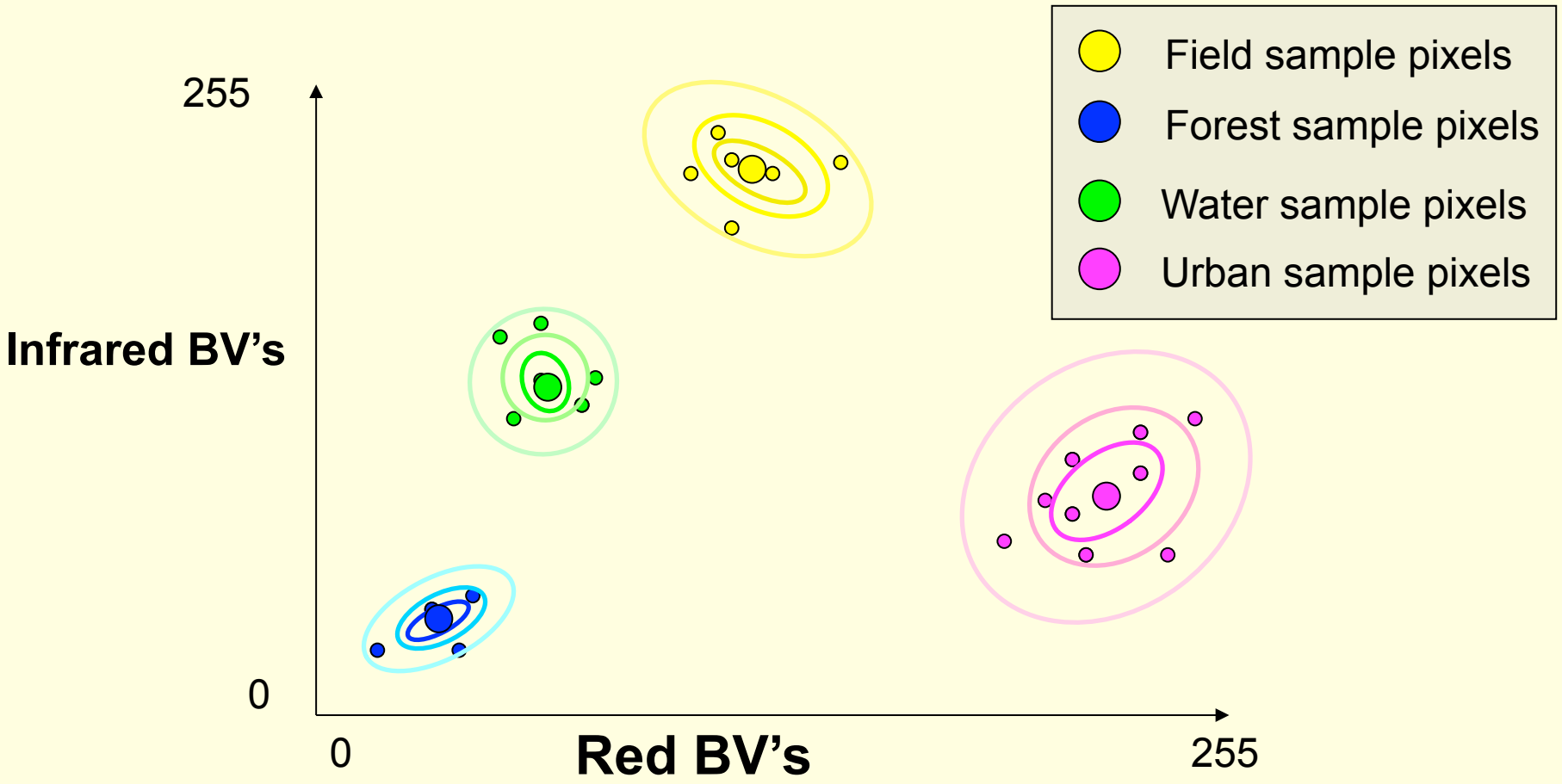
Maximum Likelihood Method

Sample pixels are plotted in spectral space using all bands. Here only 2 bands are shown.



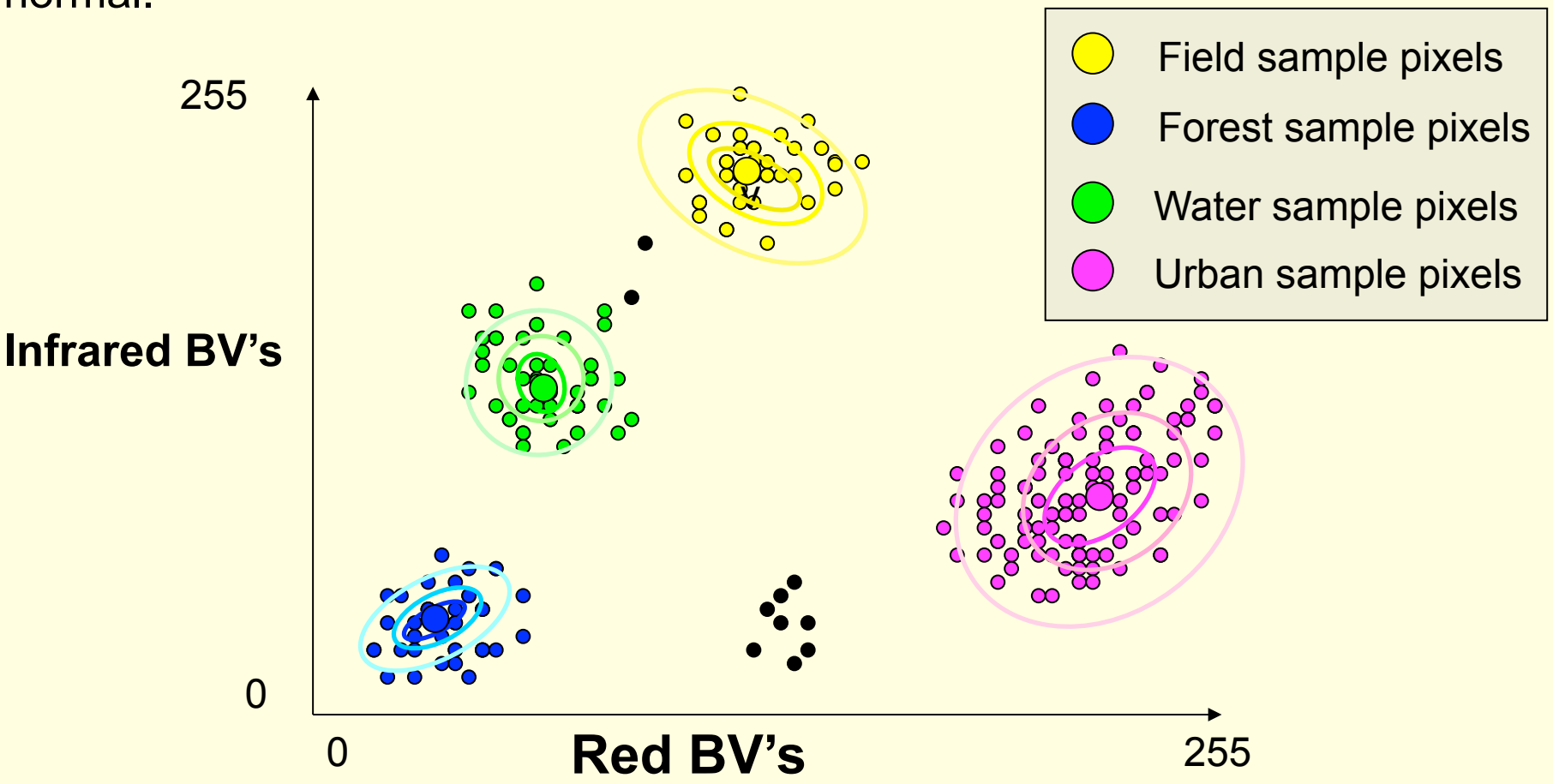
Maximum Likelihood Method

Class means, variances, and covariances are calculated.



Maximum Likelihood Method

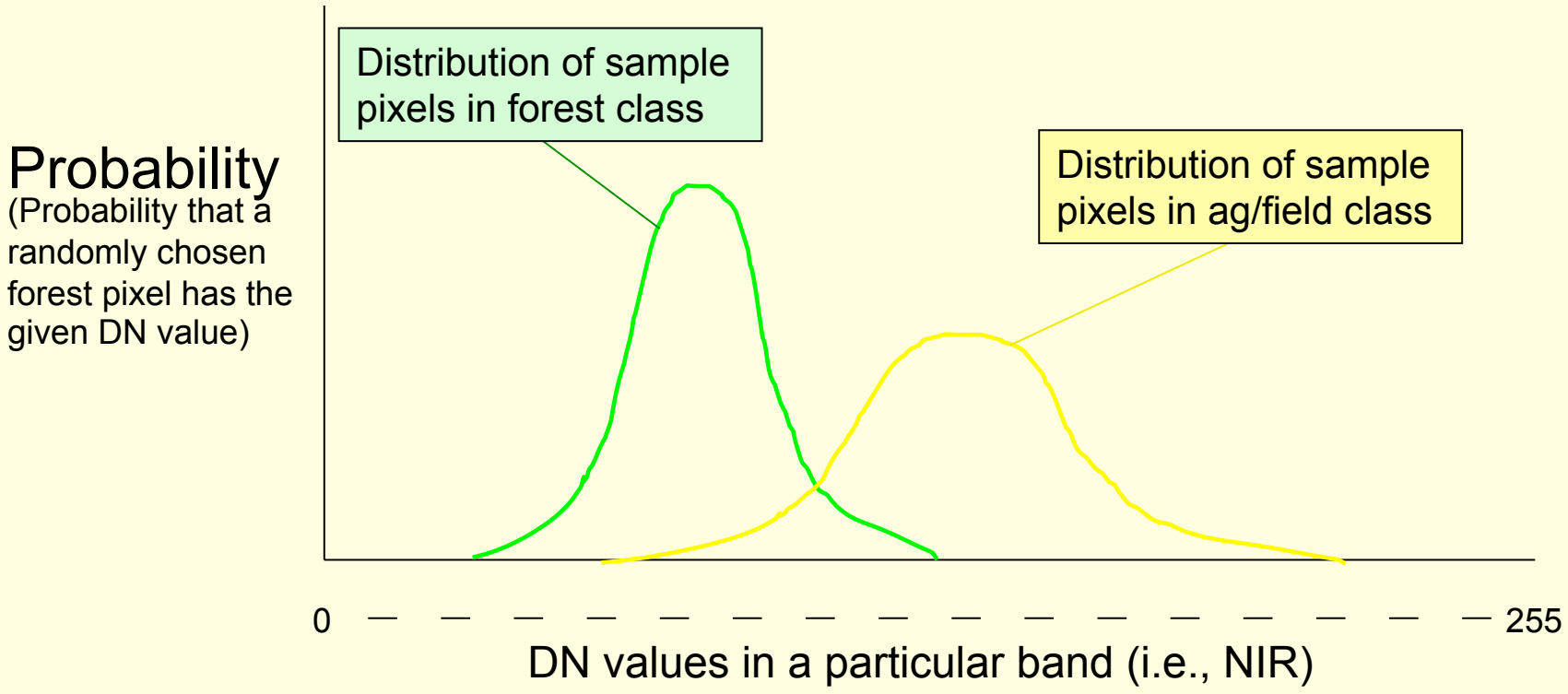
Then each (non-sample) pixel is assigned to the class for which its BV's are most likely, assuming the distribution of pixels in each class is multivariate normal.



Pixels that fall below a certain threshold (in terms of likelihood for any class) are sometimes left unclassified, as shown.

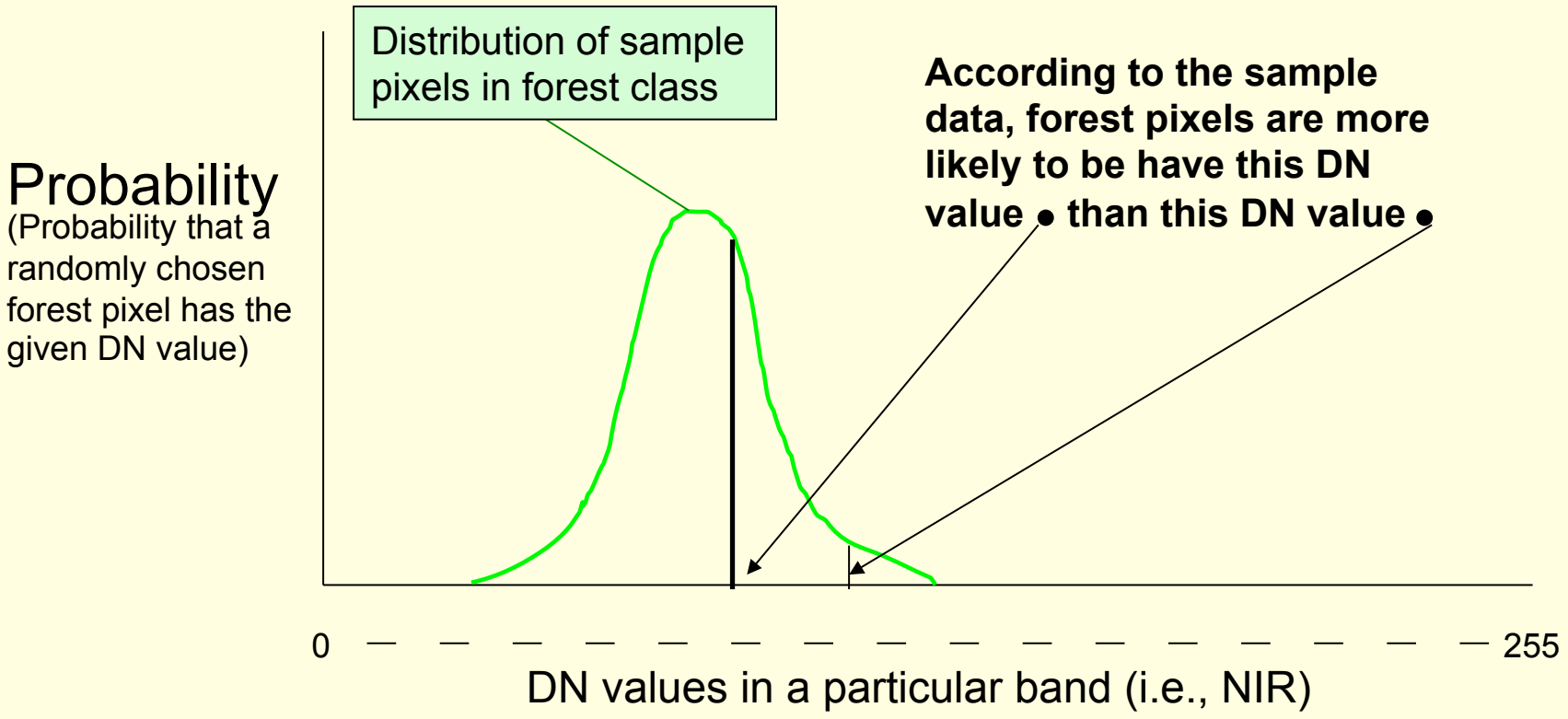
Maximum Likelihood

- How is “most likely” determined?
- Consider the problem in the one band case.



Consider curves in terms of probability

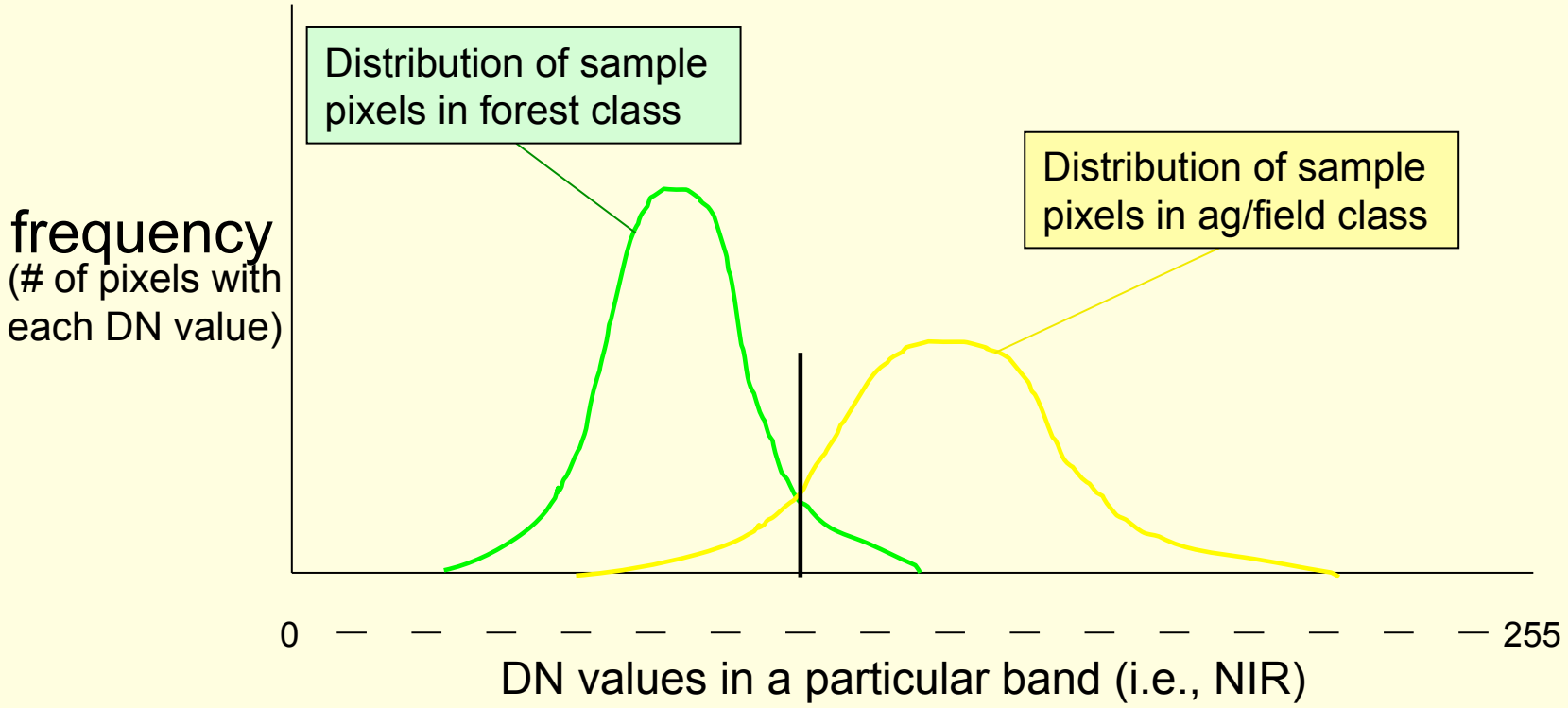
- The height of the curve at each point shows the relative probability that a random pixel in the forest class has that DN value.
- Area under curve equals 1, since all forest pixels fall somewhere under this curve



How is “most likely” determined?

Highest probability = highest Maximum Likelihood

- Pixels with a particular DN value are assigned to the class for which the likelihood (probability) is the highest.
- Therefore, the black vertical line represents the cutoff point for class membership.



This is generally done with multiple bands (in multiple dimensions).