Introduction to Change Detection

Lecture 3: Band ratios and image transformations

Instructor: Lila Leatherman (they/them)

November 17-18, 2020

Course Agenda

- Day 1 – Morning
  - 10:00-10:45 – Presentation: Course overview and image selection and preparation
  - 10:30-10:45 – Demonstration: Overview of GEE
  - 11:00-11:10 – Break
  - 11:10-11:30 – Presentation: Image correction
  - 11:30-12:00 – Demonstration: Creating cloud-free composites in EE

Tasks to complete before the next session: Exercise 1 + 2

- Day 1 – Afternoon
  - 2:00-2:30 – Presentation: Band ratios and image transformations
  - 2:30-3:00 – Demonstration: Identifying significant landscape change
  - 3:00-4:00 – Q&A and Exercise Help

Tasks to complete before next session: Exercise 3

Lecture outline:

- Review of spectral spectral bands
- Review of spectral signatures
- Band ratios
  - NDVI
  - NBR
- Image transformations
  - Tasseled-cap transformations
- Demo of band ratios and transformations in ArcMap

Introduction

Image Differencing

- Two-date method of locating change

Input types:

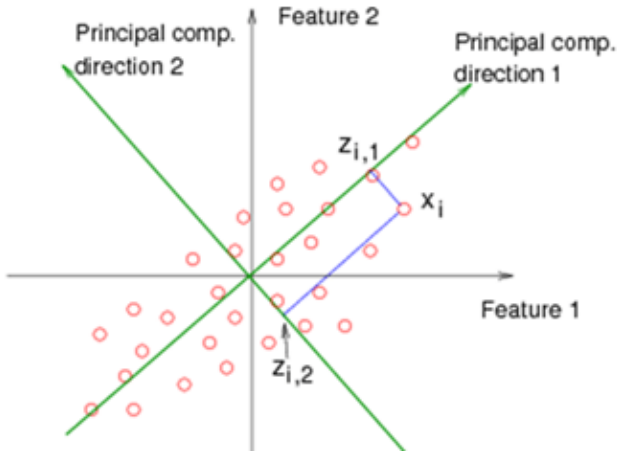
- Bands
- Classification
- Transformations

Spectral Image Enhancements

Simple mathematical:

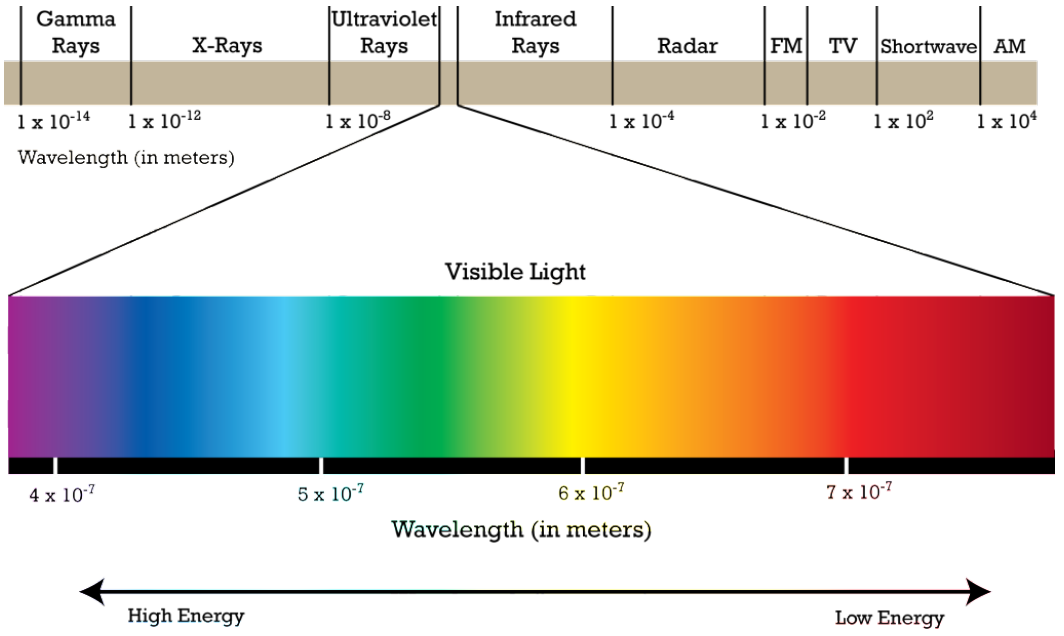
$$\text{Ratio} = \frac{Band1 - Band2}{Band1 + Band2}$$

Complex spectral:



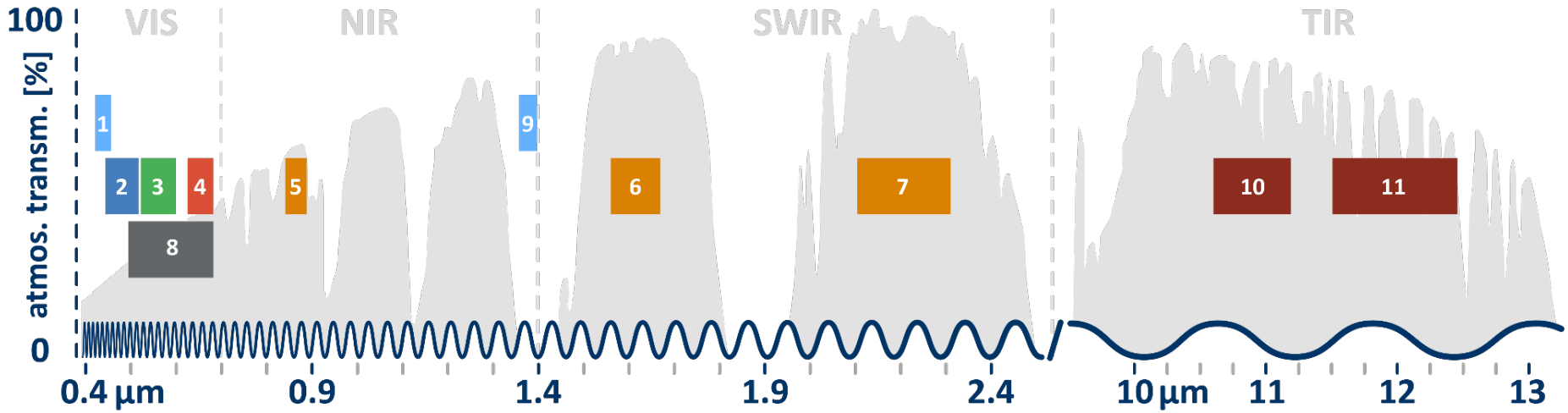
Review of spectral bands

- RS sensors can collect data in all portions of the EM spectrum
- Multispectral sensors have spectral sensitivity limitations (spectral resolution)
  - The wavelength ranges recorded by sensors are called bands or “channels”, varies with sensor



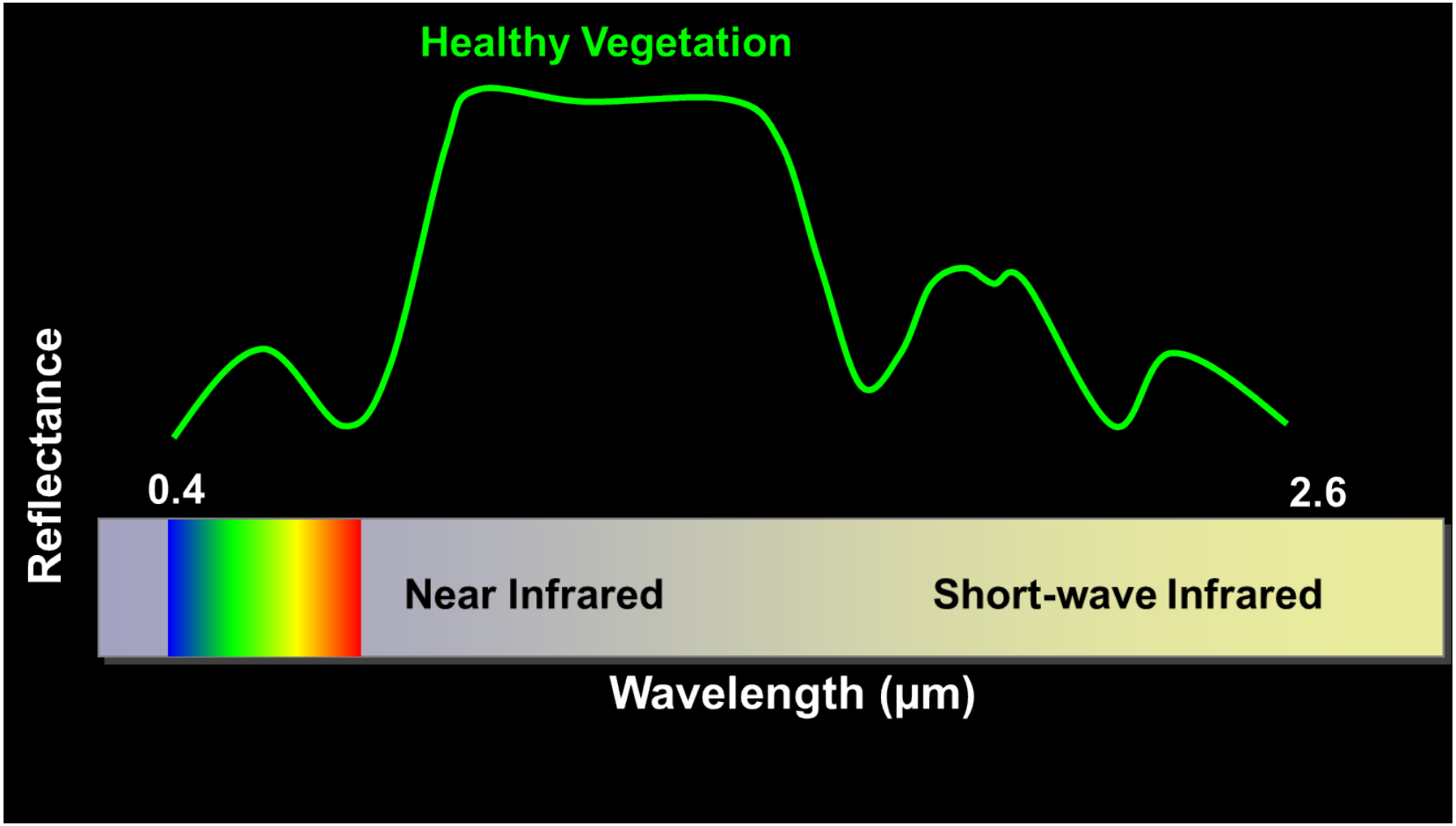
Review of spectral bands

- Landsat collects data in 11 “bands” throughout the EM spectrum



Review of Spectral Signatures

Graphically, the spectral reflectance of green vegetation in the visible wavelengths may be represented as shown...



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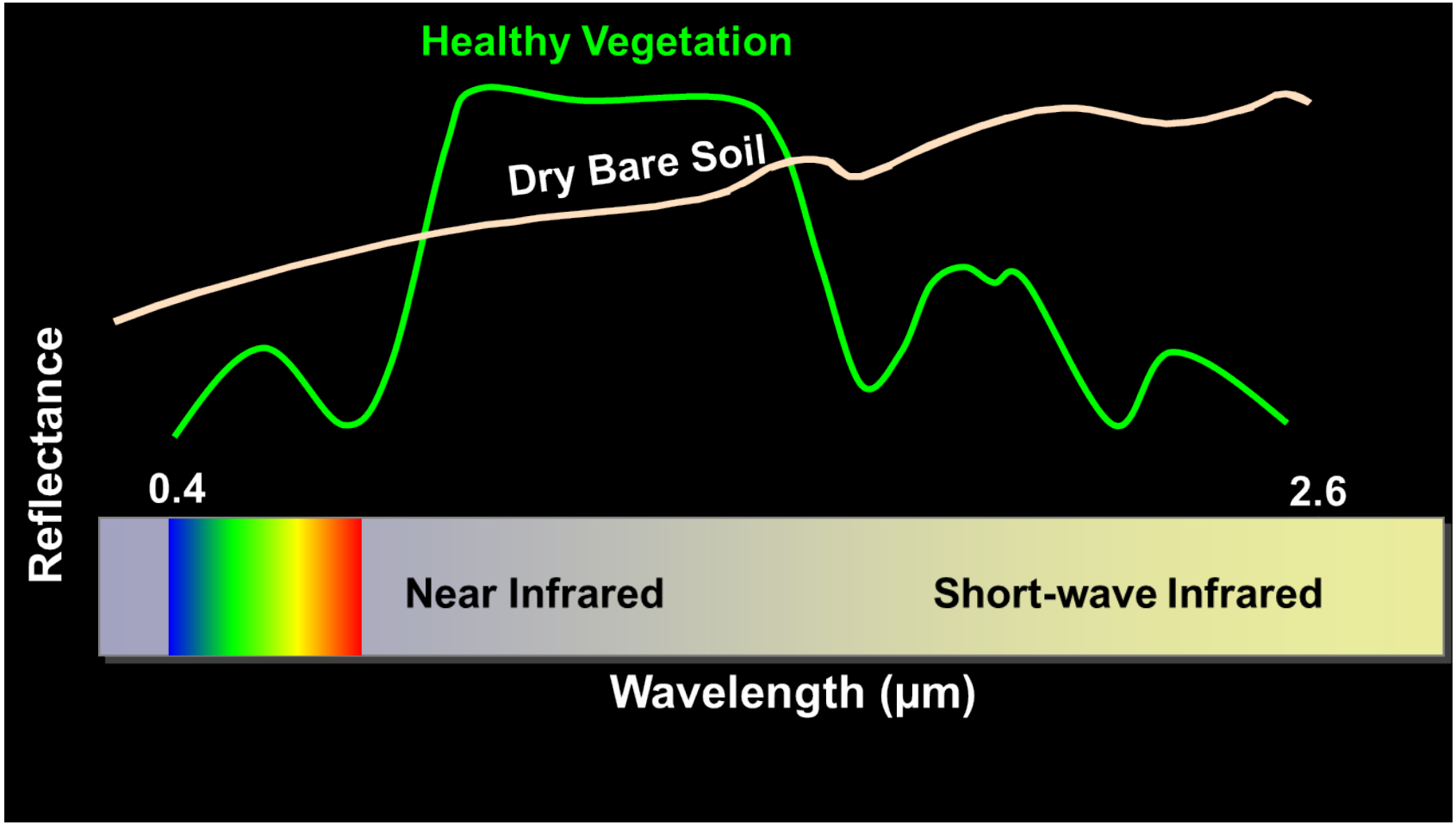

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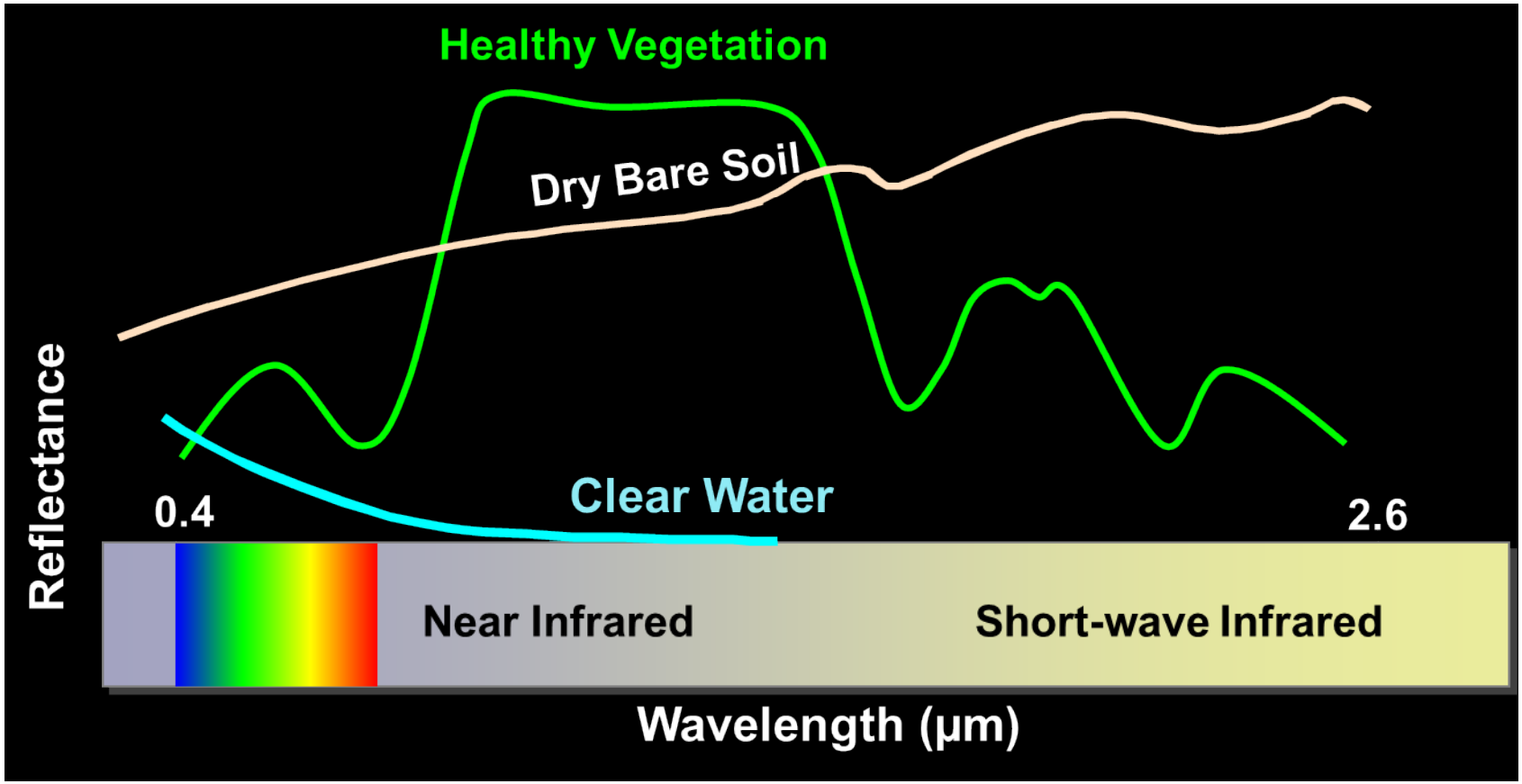
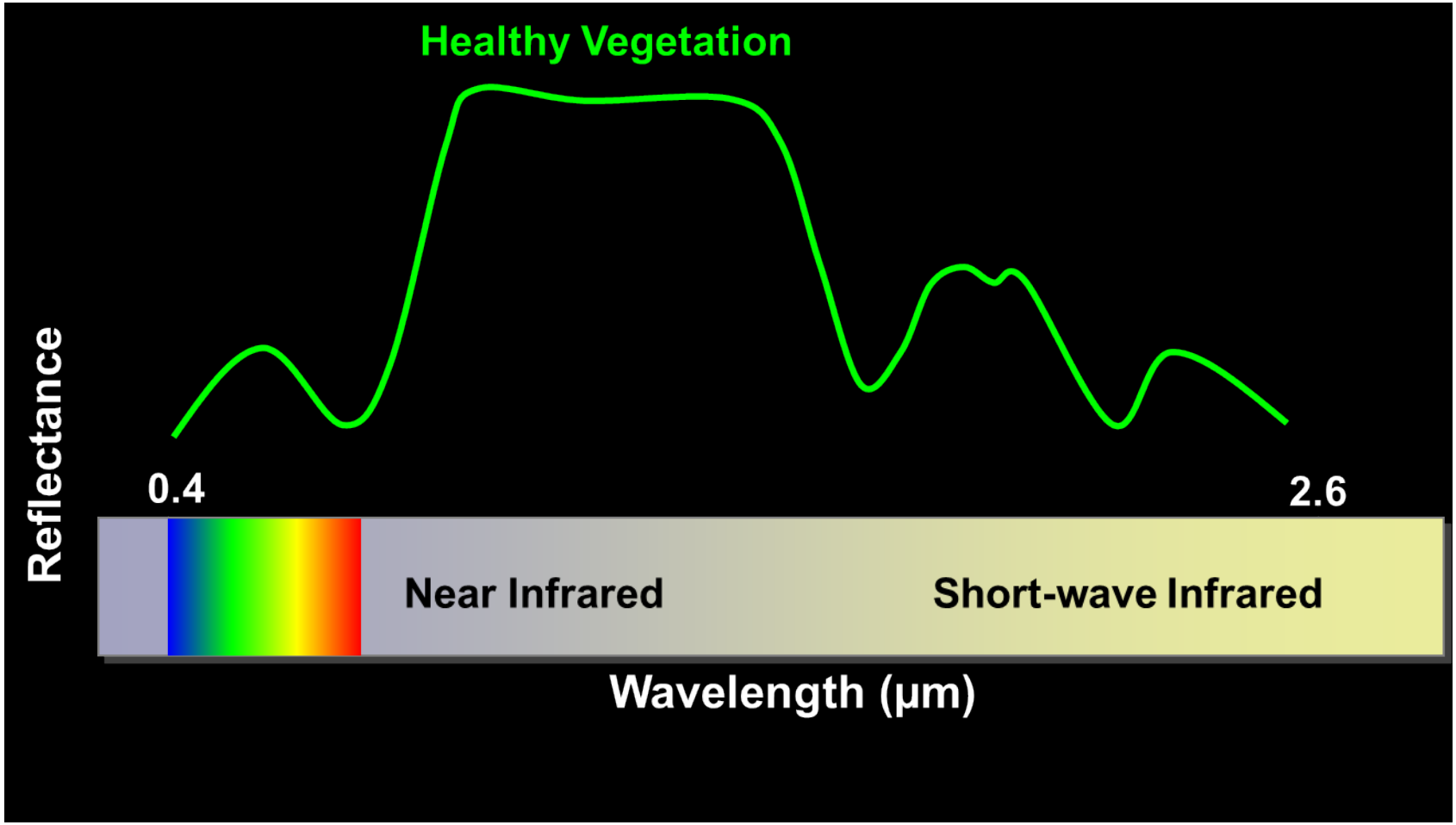


Review of Spectral Signatures

As vegetation becomes unhealthy,
spectral response curve changes.



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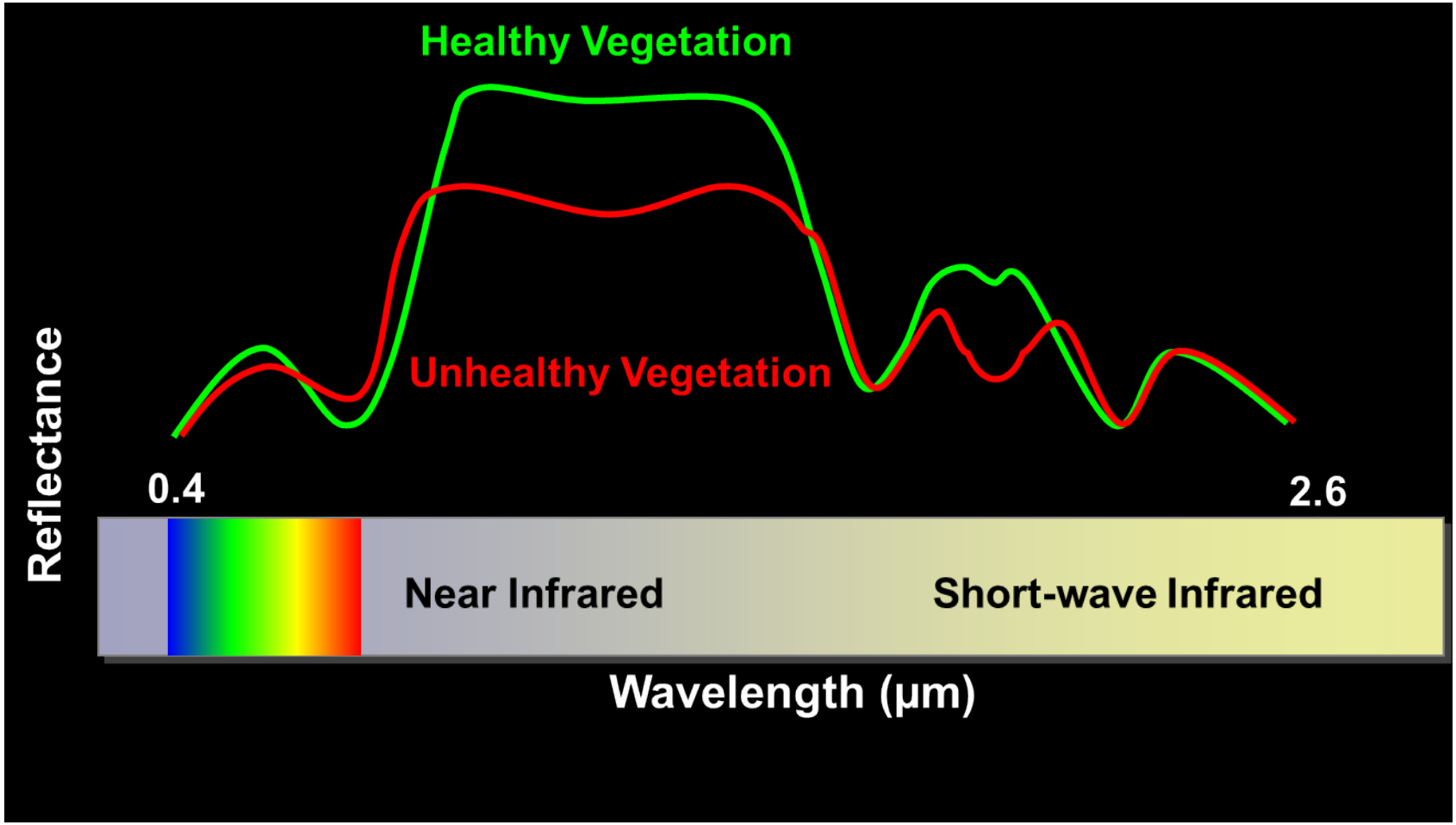
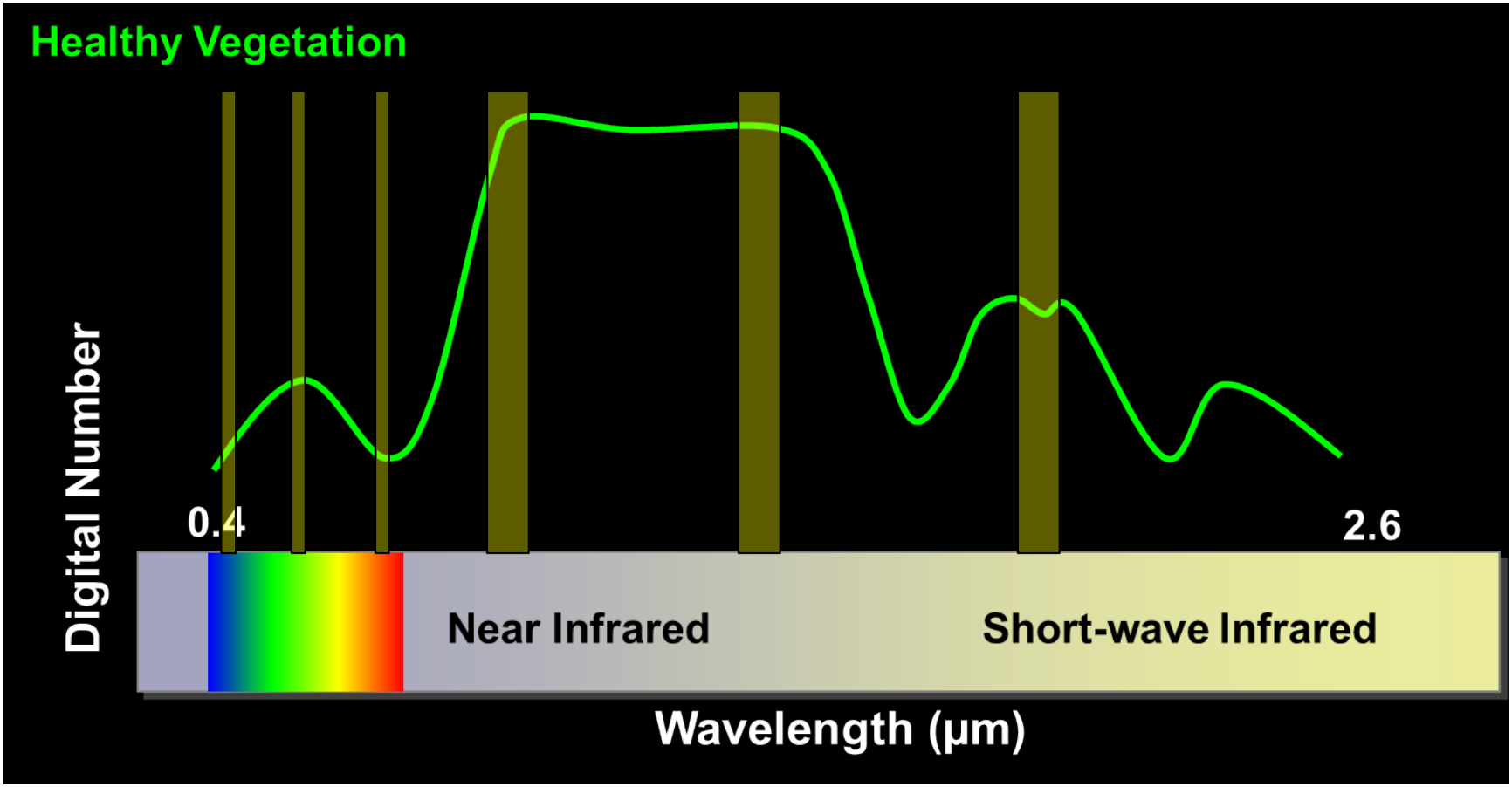


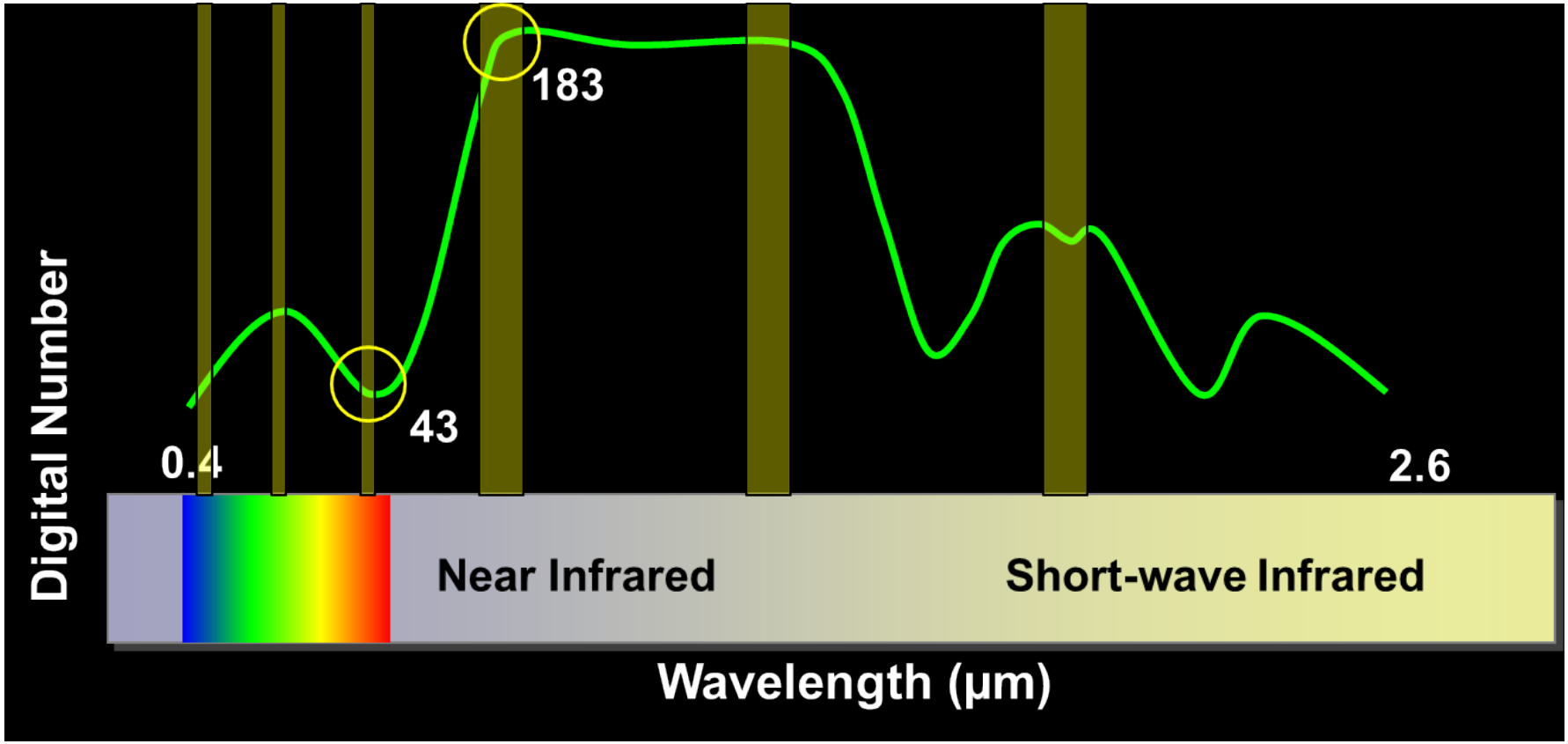
Band Ratios

Sensors capture discrete spectral information in ‘bands’ in a small portion of the full spectrum.



Band Ratios

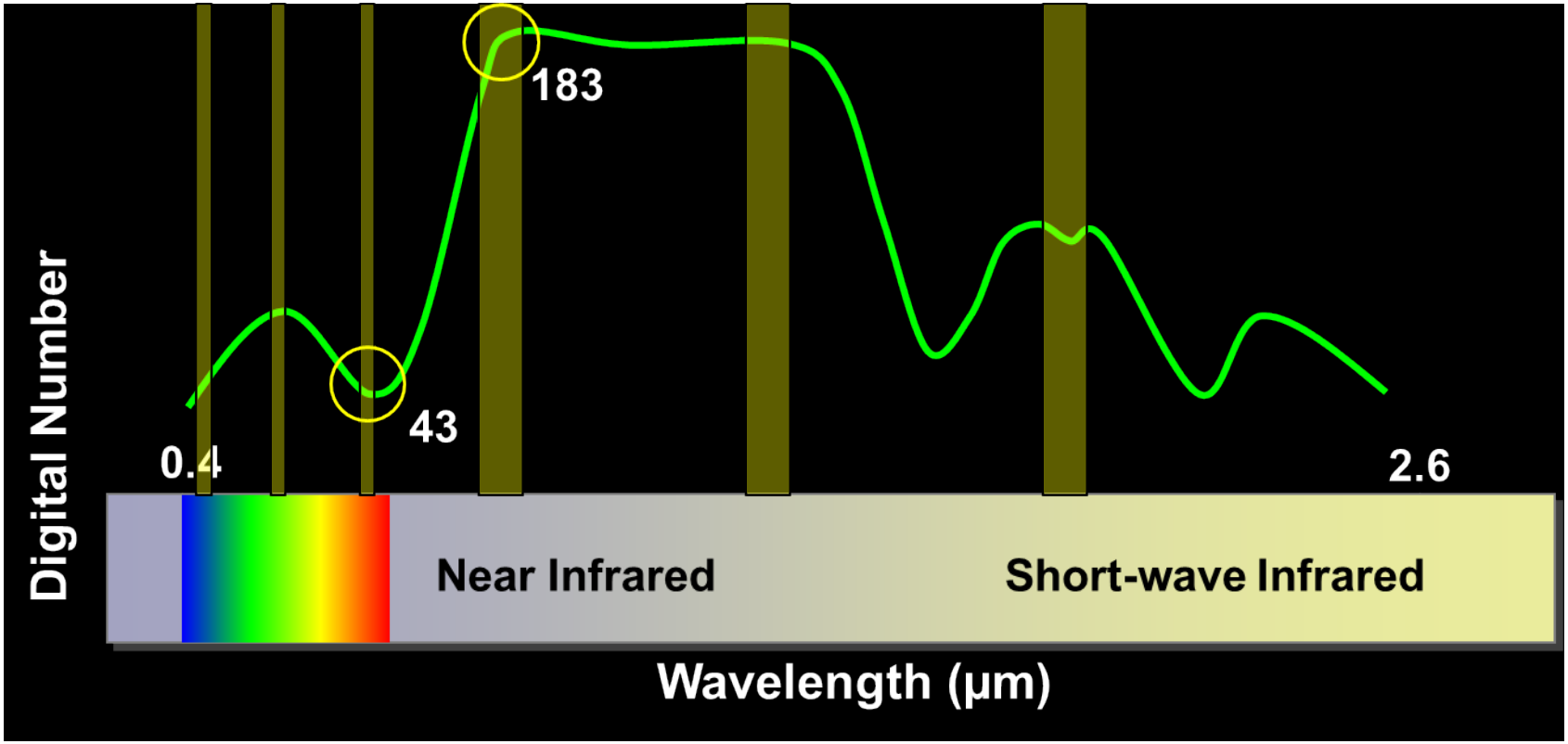
We can read these values for each pixel, and then do the math for each pixel throughout the entire image.



Band Ratios

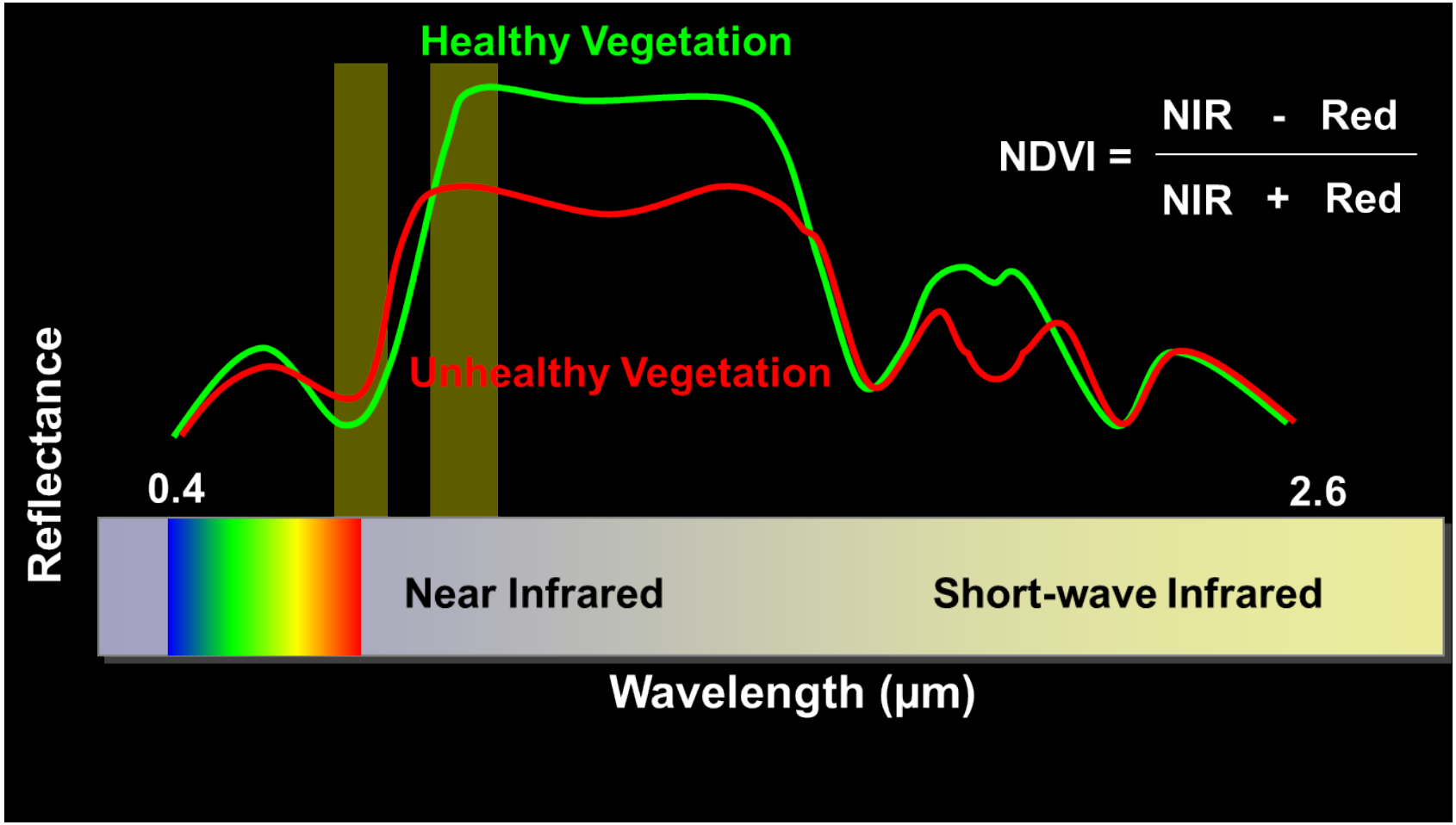
The simple vegetation ratio is simply Red / NIR, and would be:

43/183 = 0.23



Normalized Difference Vegetation Index

We make use of the spectral response of vegetation to obtain information about the vegetation…



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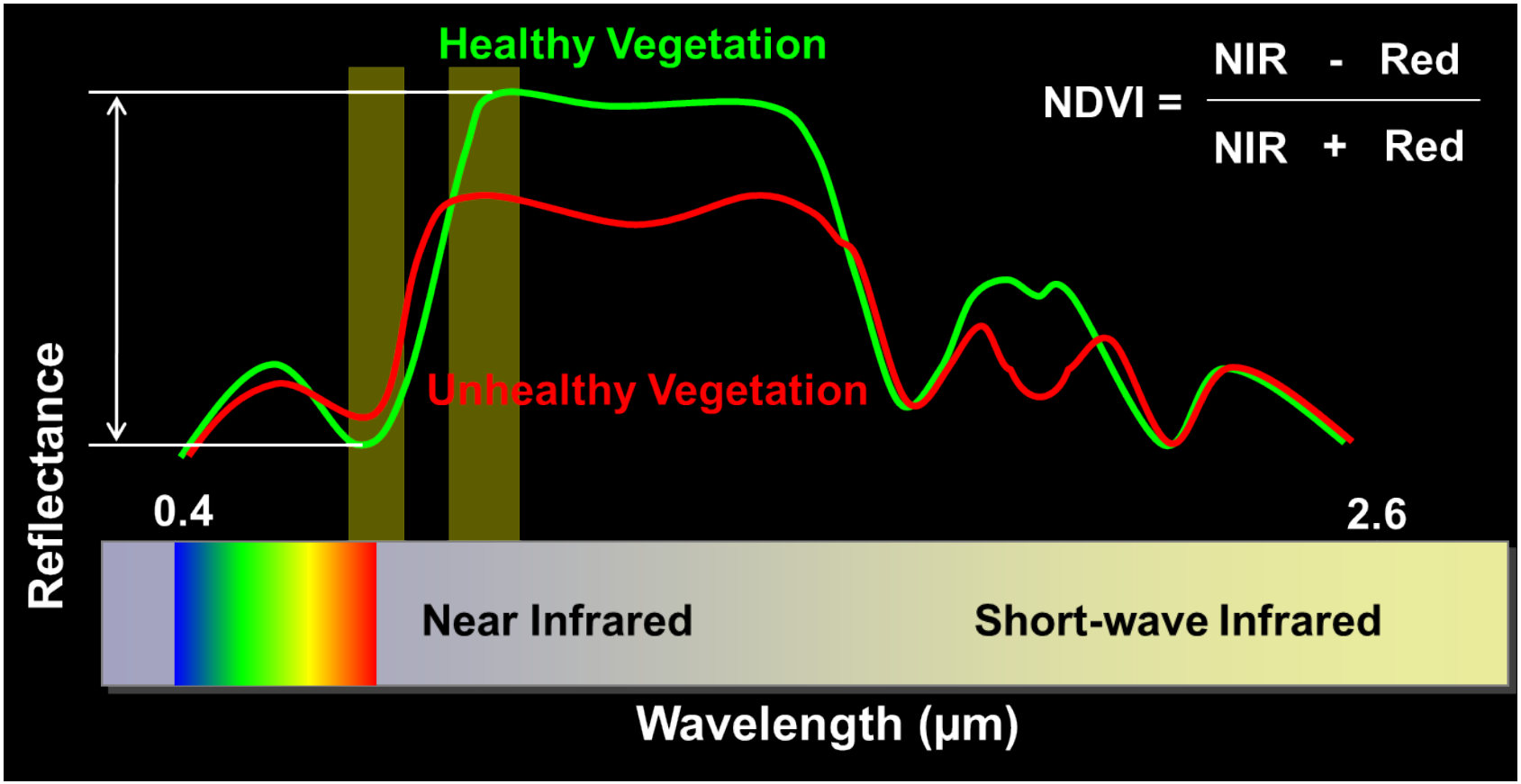
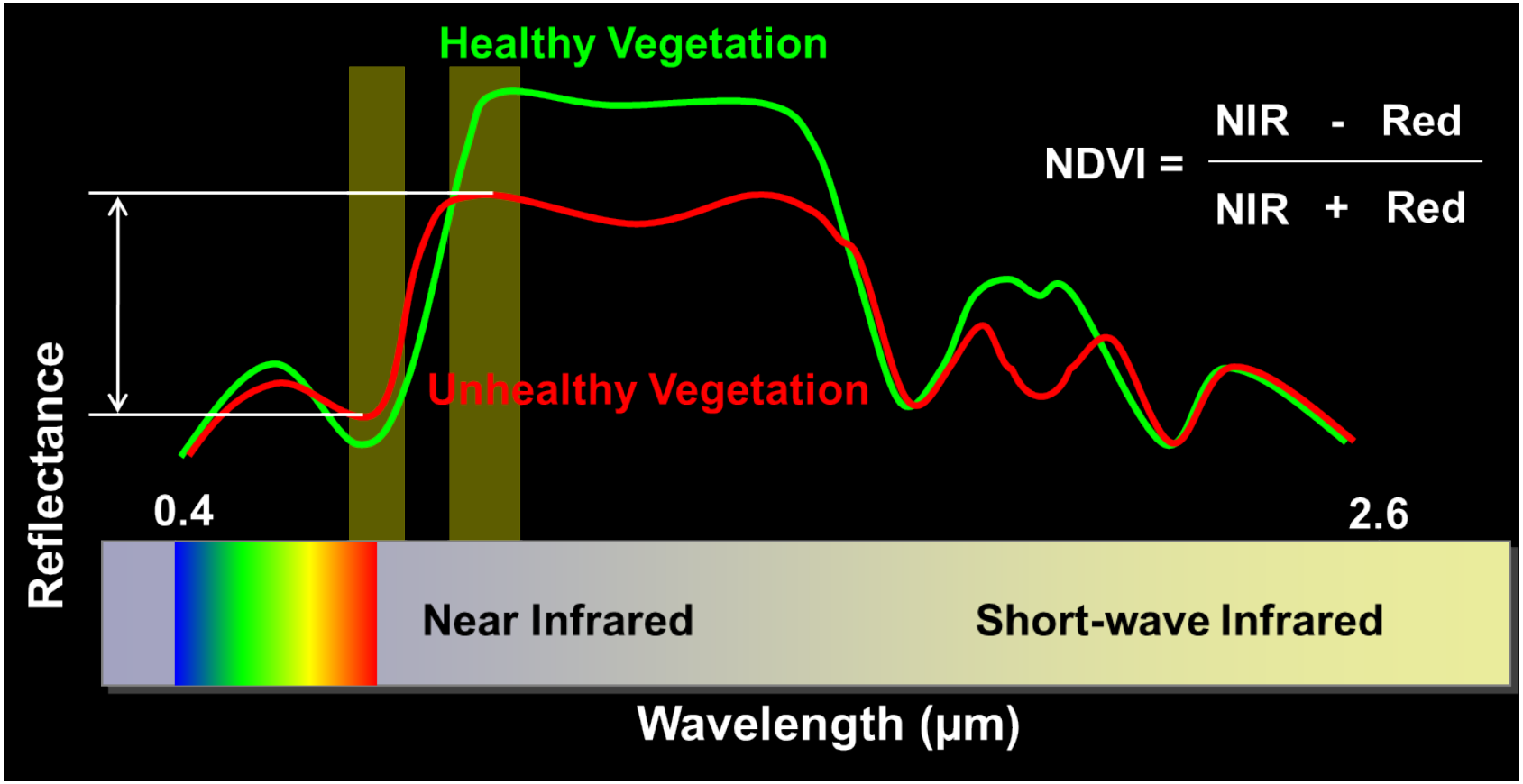


Response to EM Energy

Normalized Difference Vegetation Index

NDVI is lower for unhealthy vegetation

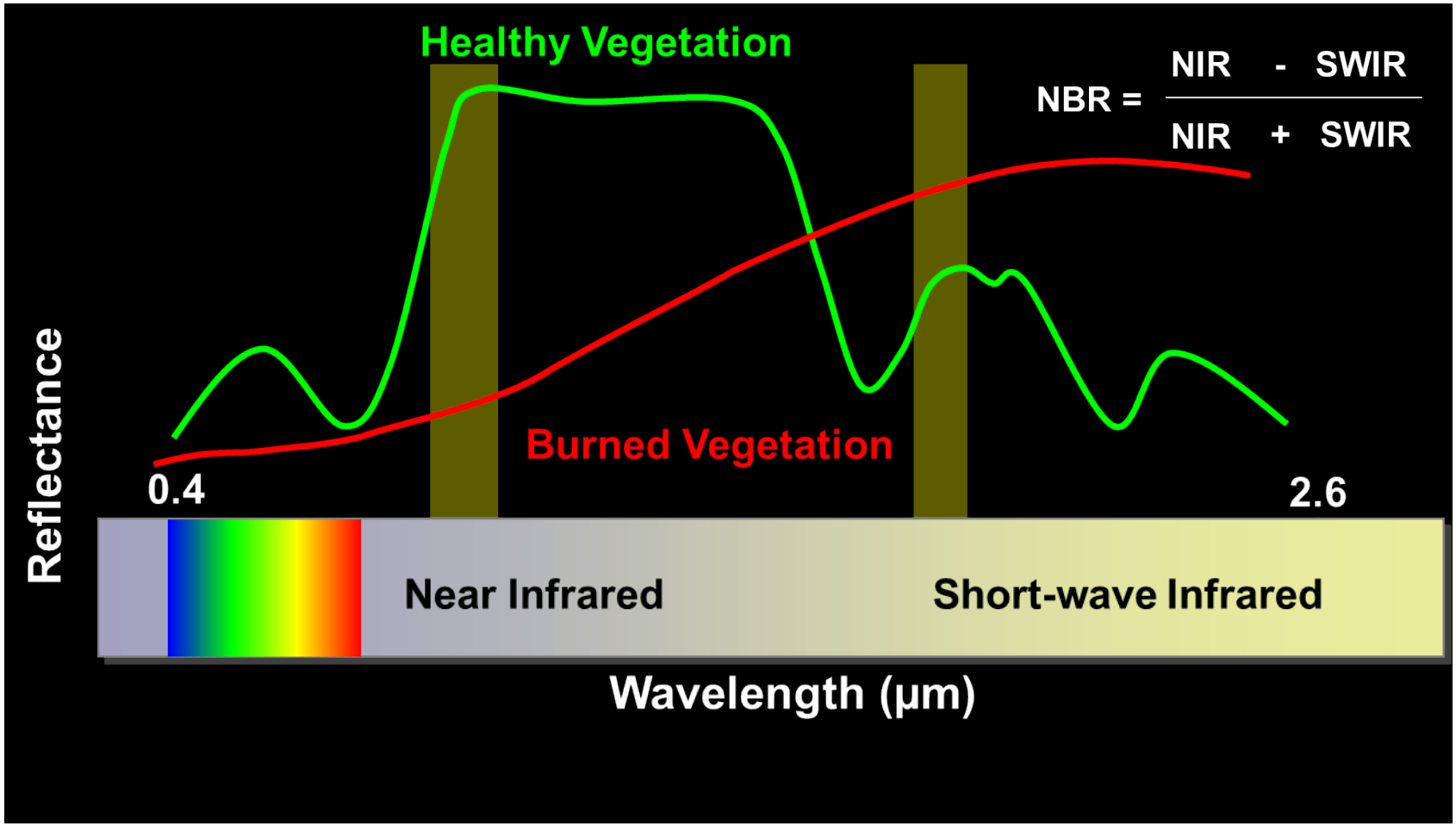


Response to EM Energy

Normalized Burn Ratio (NBR)

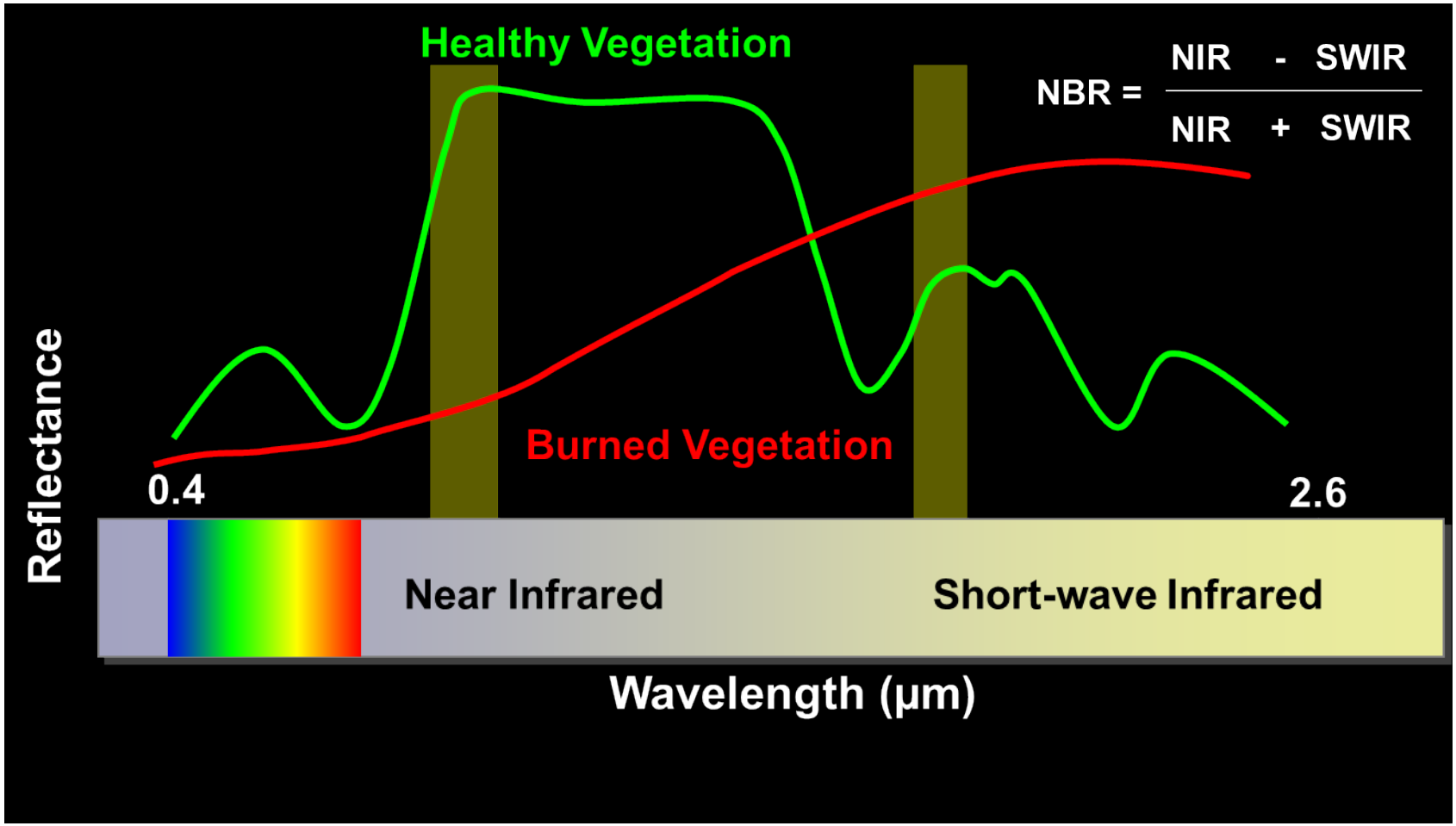
- Works on a similar concept as NDVI
- The red band is replaced with a short-wave infrared (SWIR) band
  - Band 7 for Landsat
  - Most other sensors have a corresponding band
- Improved method for delineating burned areas

Normalized Burned Ratio (NBR)



Normalized Burned Ratio (NBR)

We typically use the differenced NBR (dNBR) to provide a quantitative measure of absolute change



Band Ratios

- We take advantage of these ratios to extract information from the imagery
- Several indices have been created for vegetation analysis based on band ratios.
- The following are a brief survey of indices based on Landsat bands:

Index name	Equation	Use
NDVI	(B4 – B3) / (B4 + B3)	Vegetation health
Moisture Stress Index	B5 / B4	Indicates stress due to low moisture amounts
Leaf Water Content	-log(1- (B4-B5)) / -log(1-(B4'-B5'))	Assess water stress
Soil Adjusted Vegetation Index (SAVI)	((1+L)*(B4–B5)) / (B4+B5+L)	Removes effect of soil within pixel; value of L can vary, but 0.5 is typical
Atmospherically Resistant Veg. Index (ARVI)	B4-(B3-(B1-B3)) / B4+(B3-(B1-B3))	All terms use a special atmospherically corrected value.

Image Transformations

What are they?

- Linear transformation of multidimensional data
  - Applies scalars (coefficients) and constants
  - e.g., principal components
- Reduces data dimensionality
- Captures as much variation in the data as possible in two or three bands
- Typically done with data with much higher dimensionality.

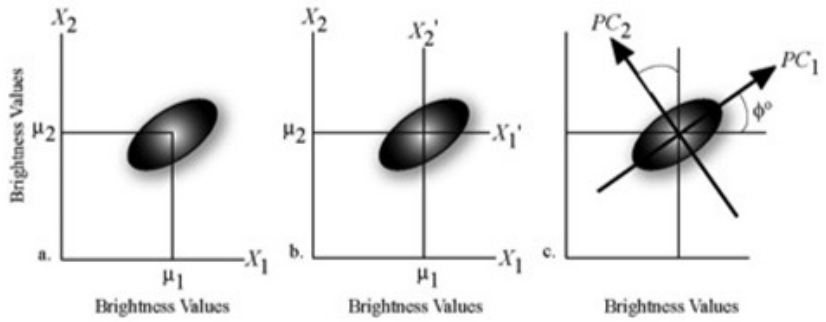


Image transformation – Tasseled Cap

- Extracts components related to geophysical properties
- First 3 bands of new image
  - Brightness
  - Greenness
  - Wetness (third orthogonal axis)
- Uses coefficients specific to sensor

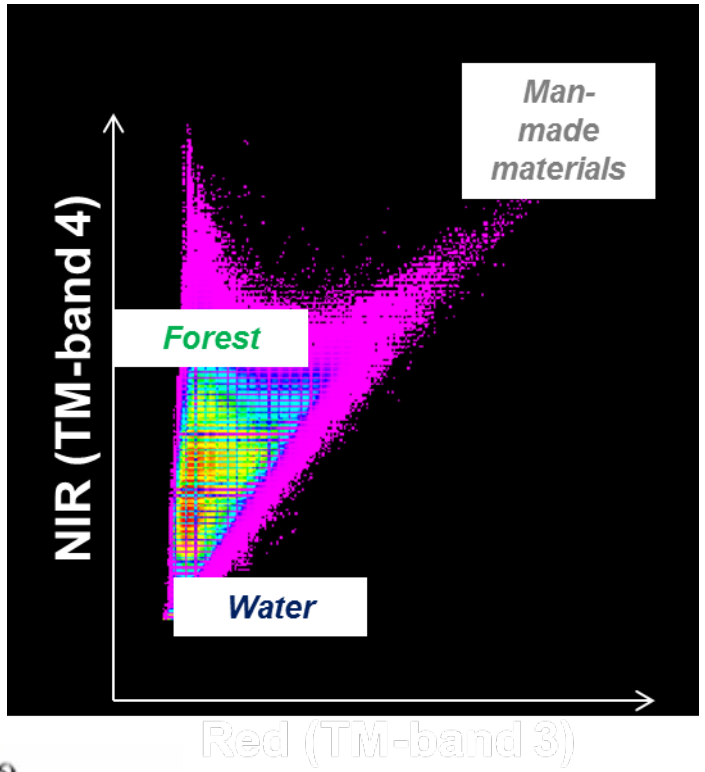


Table 6.3 Landsat-5 TM Tasseled Cap coefficient (*Source: Crist and Cicone, 1986*)

Feature	Coefficients						Additive term
	TM1	TM2	TM3	TM4	TM5	TM7	
Brightness	0.2909	0.2493	0.4806	0.5568	0.4438	0.1706	10.3695
Greenness	–0.2728	–0.2174	–0.5508	0.7221	0.0733	–0.1648	–0.7310
Wetness	0.1446	0.1761	0.3322	0.3396	–0.6210	–0.4186	–3.3828
Haze	0.8461	–0.0731	–0.4640	–0.0032	–0.0492	0.0119	0.7879
Fifth	0.0549	–0.0232	0.0339	–0.1937	0.4162	–0.7823	–2.4750
Sixth	0.1186	–0.8069	0.4094	0.571	–0.0228	0.0220	–0.0336

Image transformation – Tasseled Cap

7-band Landsat
TM5 image

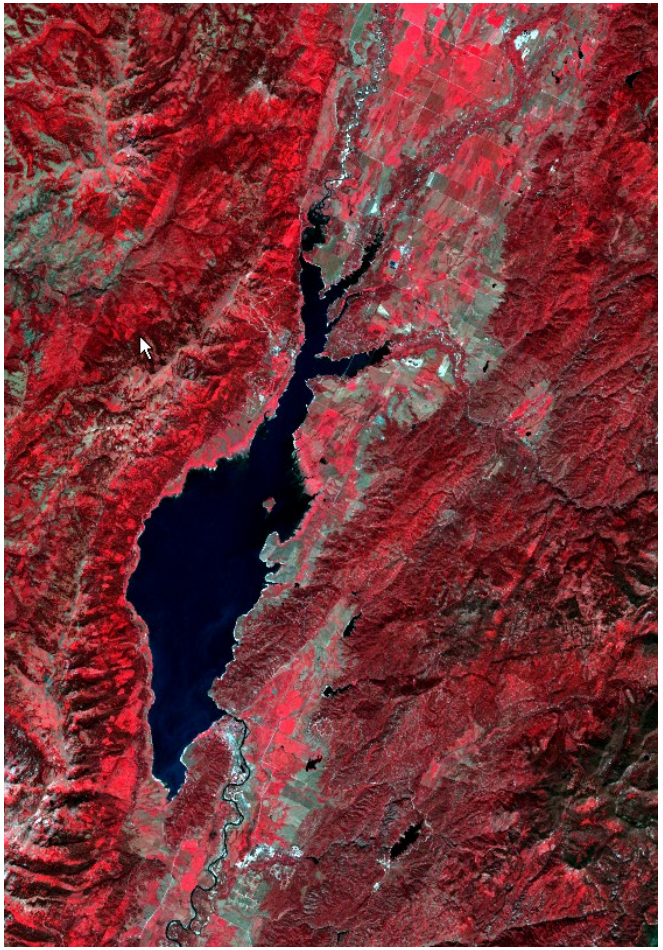


Image transformation – Tasseled Cap

3-band Tasseled Cap image

Brightness

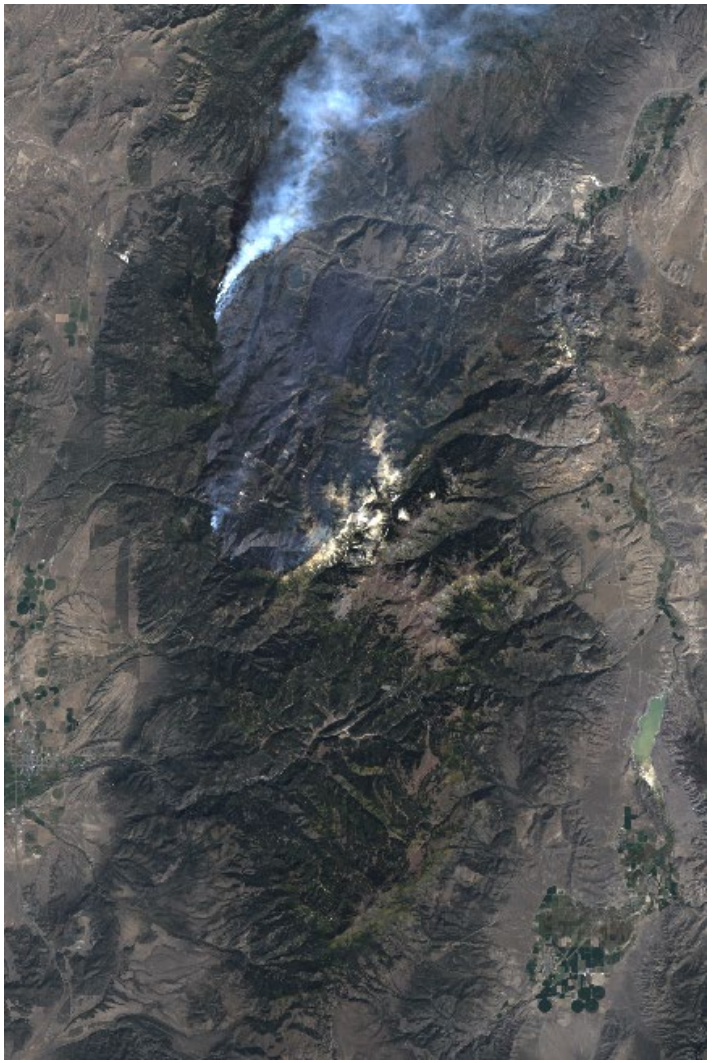
Greenness

Wetness

Using image enhancements to map change

In Exercise 3, you will

- learn how to create band ratios and image transformations using ArcGIS
- investigate how certain landscape features appear through the lenses of different image enhancements
- observe differences in images/bands when landscape changes have occurred



Demonstration

Exercise 3: Image Enhancements in ArcGIS