

# Band ratios

Spectral Band ratioing is perhaps the simplest of multispectral techniques, - a type of *GIS 'overlay'* ... *deriving new information from two data layers*

A band ratio is a new channel of data created by the simple division of two sets of band digital numbers  
..... for each pixel

$DN_{new} = DN^a / DN^b$  for each pixel where a and b are bands

e.g. for a pixel, if band a = 50 and band b = 25, then the ratio  $DN = 50/25$  for that pixel  
 $DN_{new} = 2$  (2.0)

if a = 100 and band b = 40, then the band ratio  $DN = 2.5$   
(or rounded to 2 if there are only integer DNs)

# Band ratios

Band ratio DNs (8-bit) could hypothetically range from: 0-255  
(e.g. if 8-bit band data ranges from 0 or 1 to 255)

But in practice they rarely exceed: 0-5

The result is 'naturally' decimal, but can be written to:

- a. 32 bit 'real' channel (decimals) - if 'real' DNs are needed
- b. 8-bit (Integer) - not 16-bit as DNs won't exceed 255

A (scalar) multiplier can create values to fill 8-bit or 16-bit range

e.g if DNs range from 0-5, multiplying them by 50 would give 0-250

- This takes less space than a 32 bit real channel (but do we care anymore ?)

# Ratio DN values

So we have 3 options:

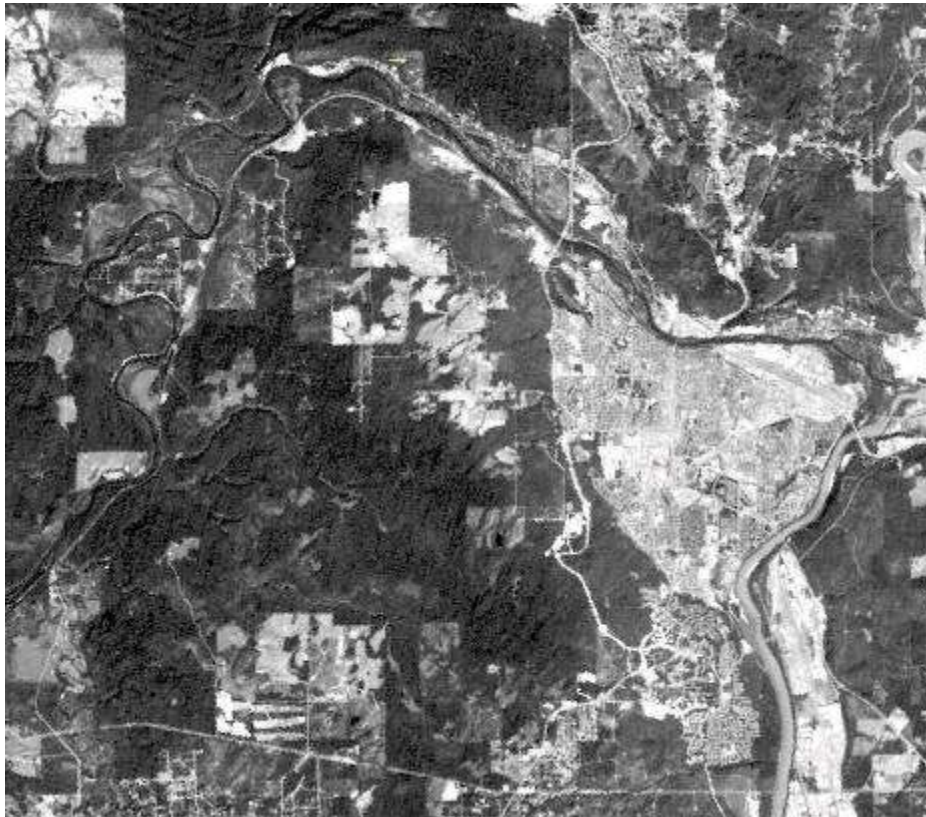
1. Retain decimal values e.g.  $50 / 12 = 4.167$  (32-bit channel)
2. Write to 8-bit:  $DN^a / DN^b$  may give a useful 'slice' identifying  
(e.g. new DNs = 0, 1, 2, 3, 4, 5 )
- 3a. Multiply by a scalar value e.g. 10 or 50 to 8-bit range (0-255)
- 3b. Select a software 'auto' option to fill the 8-bit (or 16-bit) data range

# Why use band ratios ?

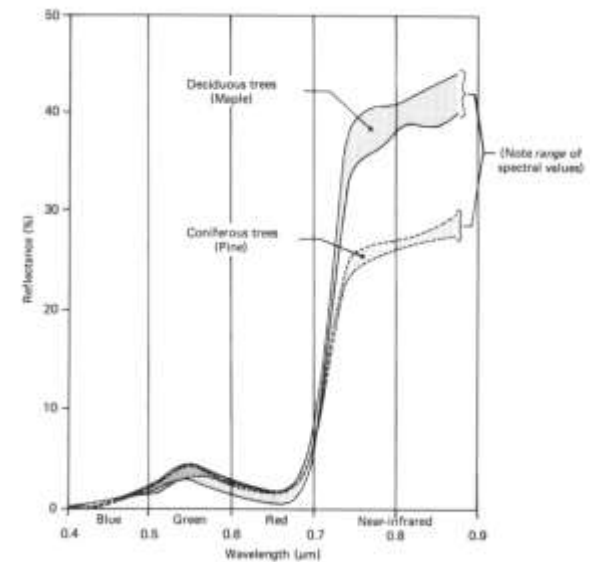
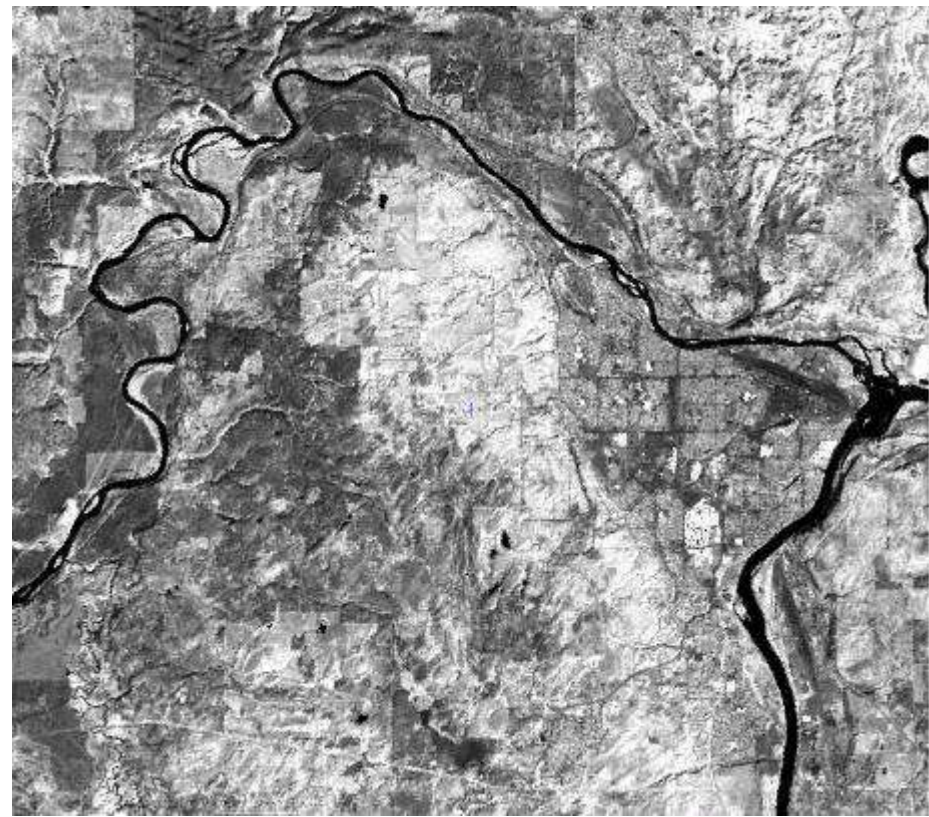
They create a new set of data that may highlight features. This cancels or reduces what is common in two images and exaggerates contrasts.

e.g. NIR/Red is a common ratio = TM 4/3 or OLI 5/4

[Band 3](#)



[Band 4](#)



# Band ratios

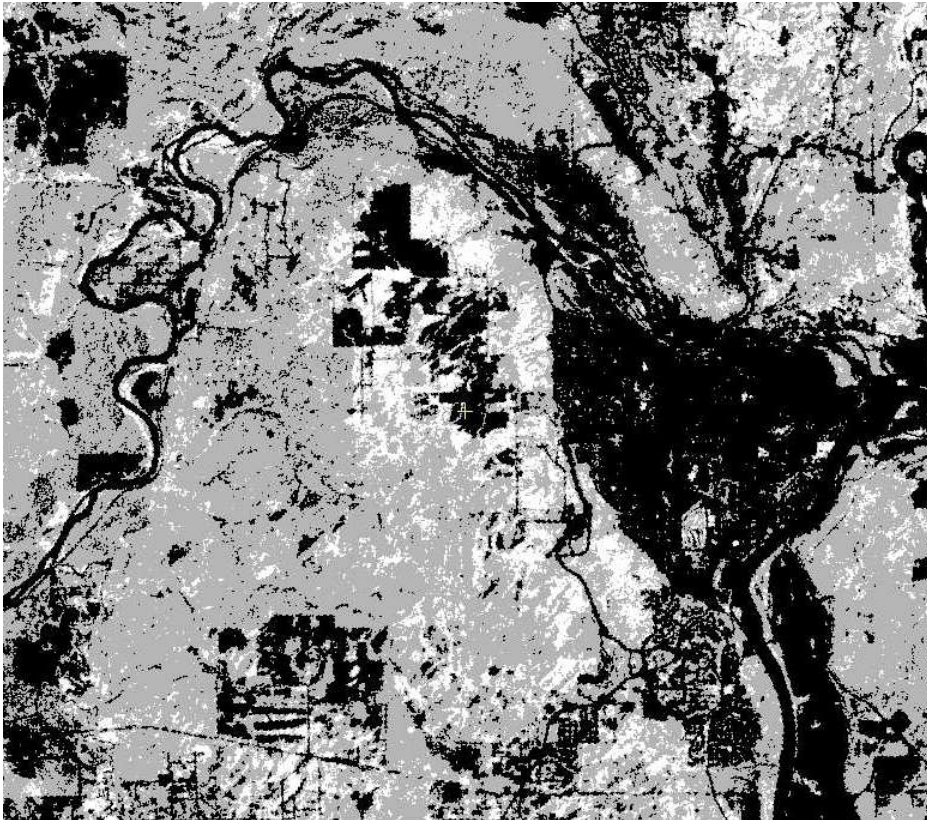
TM4/3 ratio - no scalar (DNs 0-3)

Scaled or 32-bit: DN's ~ 0-255

Vegetation > 1;      water < 1

continuum of DN's

0: Water, 1: Urban, 2: treed, 3: deciduous ?



Landsat MSS bands 1-4 (also known as = 4-7)

Possible ratios =  $n(n-1) = 12$

● **Table 4.** Some commonly used Landsat MSS ratios and their applications. Adapted from Avery and Berlin (1992, p. 442).

MSS Ratios	Applications
1/2, 1/4, 3/4	Characterizing rocks and soils
1/2 or 2/1	Suspended sediment in water
1/2 or 2/1	Iron-oxide content in rocks
3/1, 3/2	Vegetation and water bodies
4/1, 4/2	Vegetation and water bodies

Note: the inverse ratios create negative images, which may be more pleasing visually for certain features.

[http://academic.emporia.edu/aberjame/remote/landsat/landsat\\_proc.htm](http://academic.emporia.edu/aberjame/remote/landsat/landsat_proc.htm)

Landsat TM sensor : six reflectance bands -> 30 (6 x 5) ratio combinations - 15 original and 15 reciprocal.

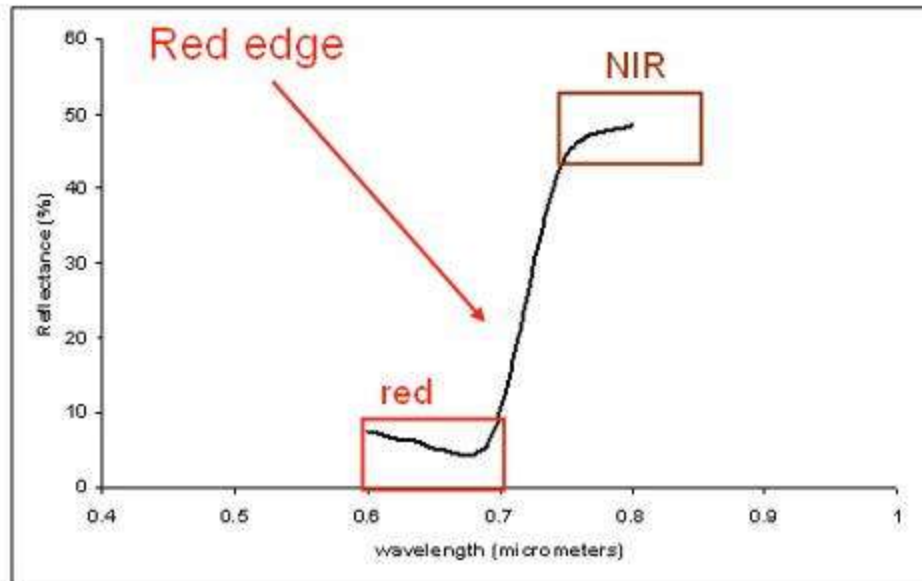
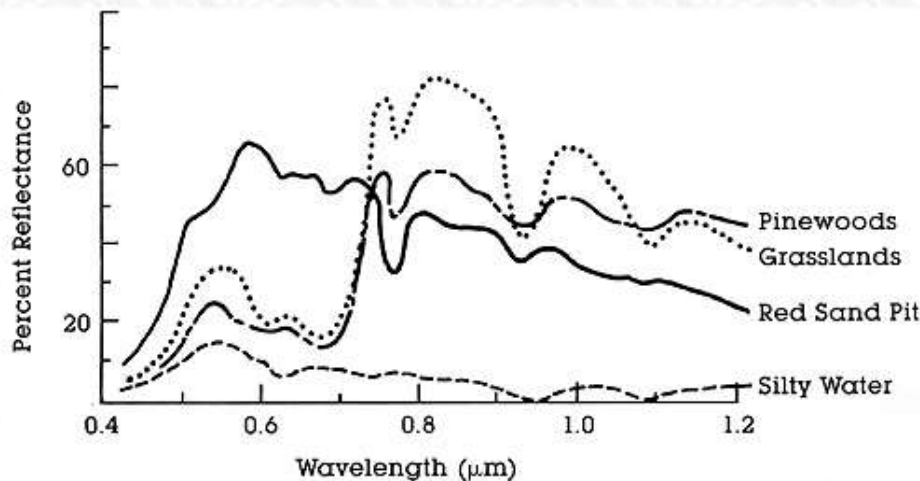
[https://web.pdx.edu/~nauna/resources/10\\_BandCombinations.htm](https://web.pdx.edu/~nauna/resources/10_BandCombinations.htm) (see bottom section)

# Role of ratios: a. Spectral slope enhancement

band ratioing can emphasise the difference between (adjacent) spectrum sections in an image, the most common being the Infra-red and red.

Since healthy vegetation has high reflectance in IR and low in red, any IR/Red (or any visible wavelength) will enhance vegetation differences: 'the red edge'

**Higher values (NIR/red) = more vegetation (biomass)**  
... more clear than band 4 alone

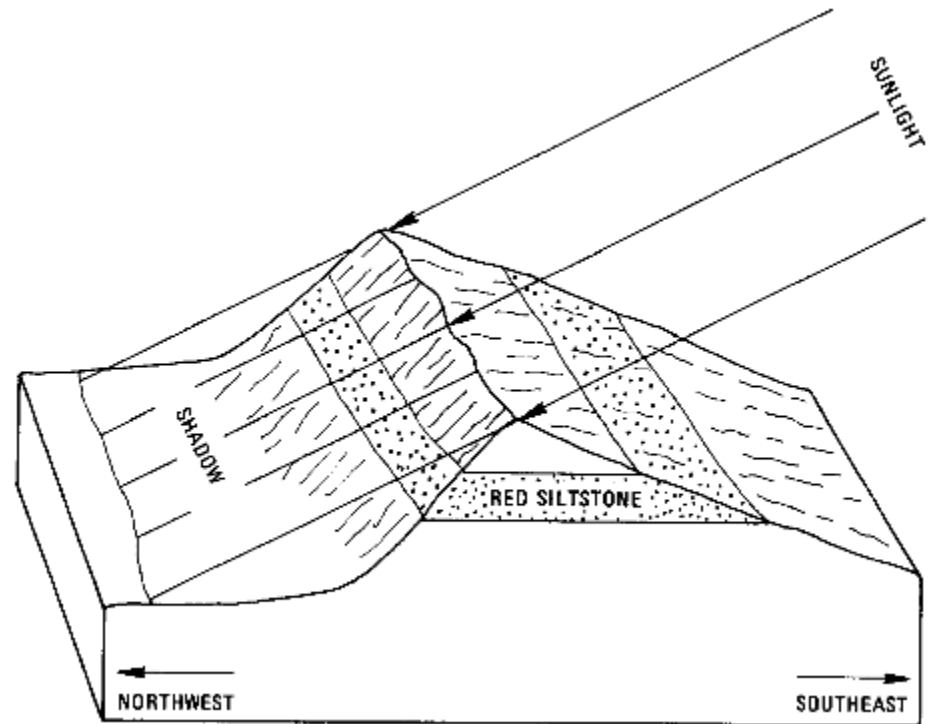


## b. reduce topographic effect (shadow)

Digital Numbers can be composed of three elements:

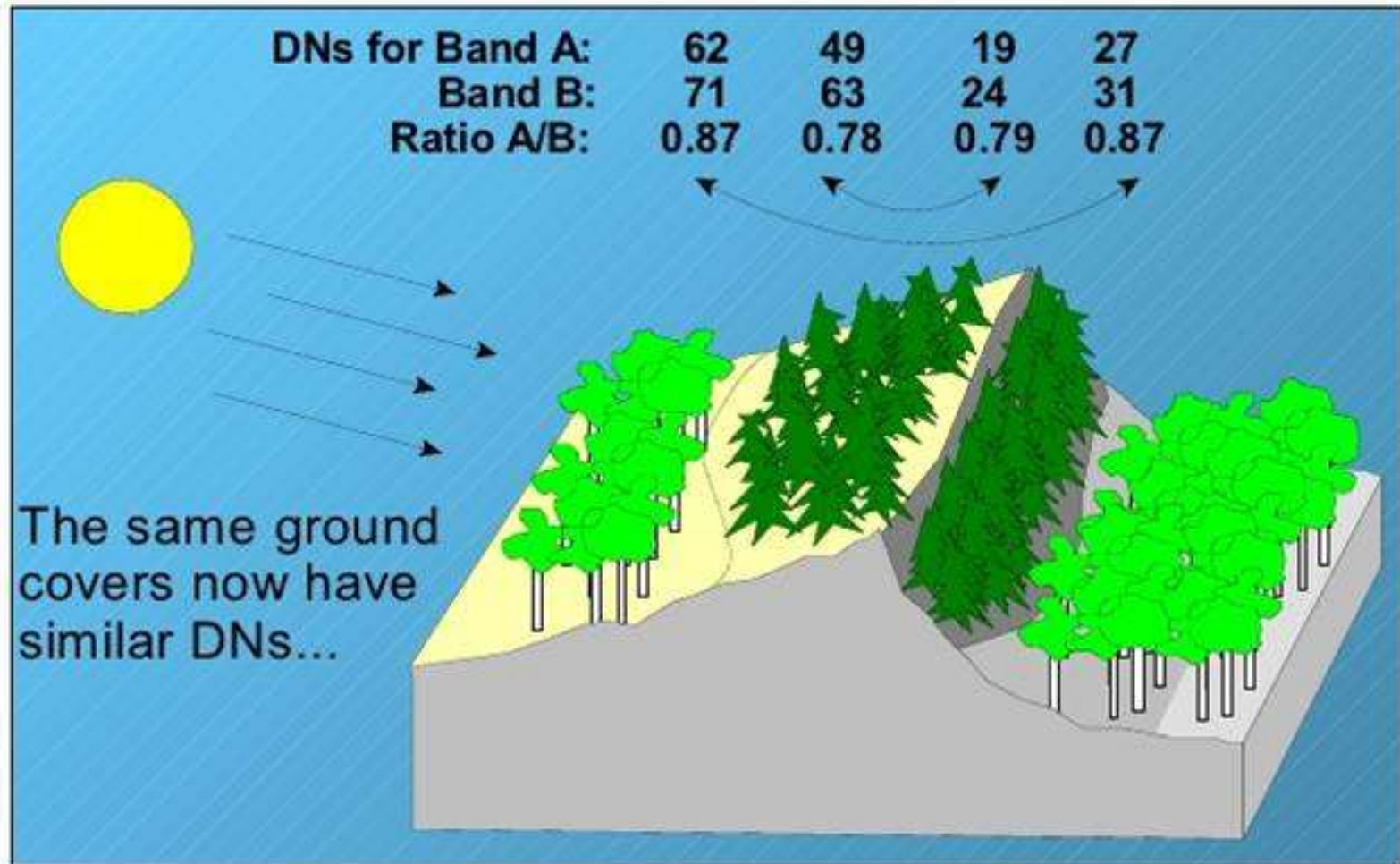
- a. Atmospheric interference (e.g. haze)
- b. Illumination (angle of reflection)
- c. **Albedo (response to surface cover)**

A ratio can reduce the effect of illumination from topography and better highlight the differences in surface cover.





# Ratio of Band A to Band B



## TM Band 4

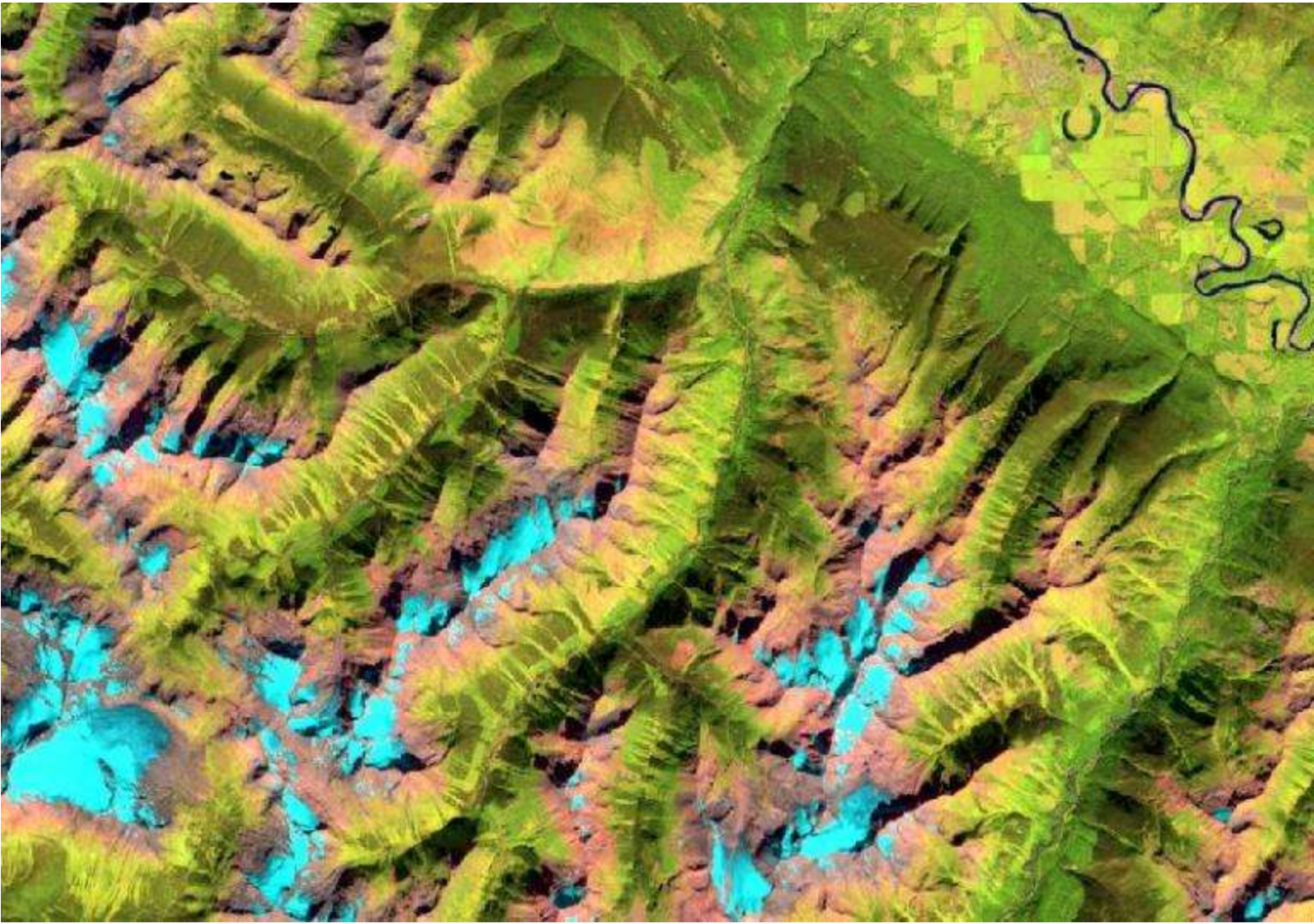
Note suppression of shadows in the ratio (eskers north of the Nechako)

## Band 4 / Band 3 ratio

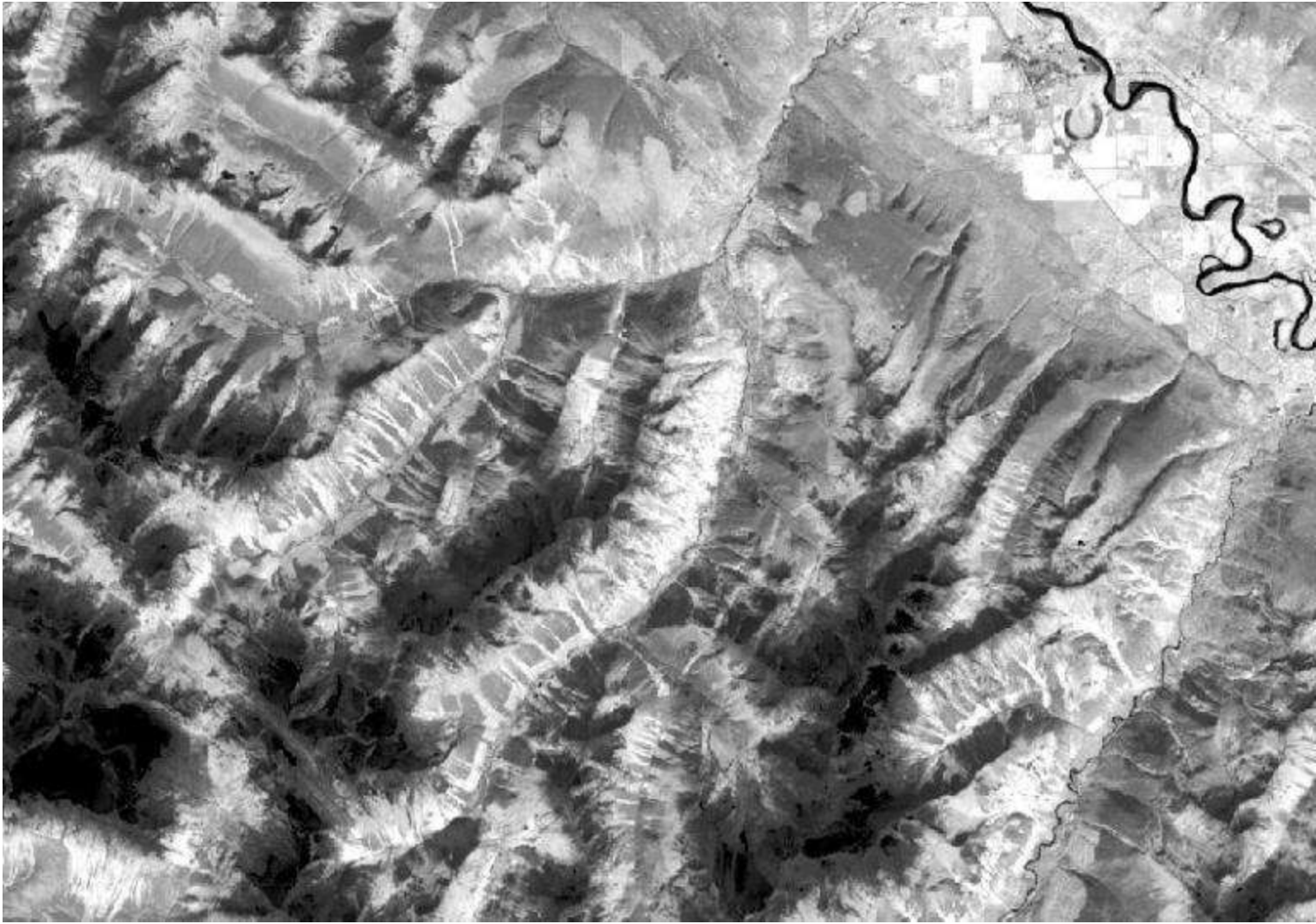


Could this ratio help distinguish the shadows from water in one channel... (lab next week)

McBride 2014 Landsat 8 OLI



NIR/Red ratio = OLI 5/4 vegetation > 1.0 ??



In mountain landscapes, a ratio may only partly correct for illumination

Red/MIR ratio = OLI 4/6 snow/ice > 2.0 (or maybe 1.5)



More on this when we discuss glacier mapping

## **Use of ratios: c. Threshold for a feature type or include as input to classification**

To include ratios as input channels for classification, they maybe should be on a similar numeric scale ?

➤ **Landsat 5 TM: 8-bit 0-255**

➤ **Use scalar multiplier ~ 50-100**

➤ **Landsat 8 OLI: 16-bit 0-63,354**

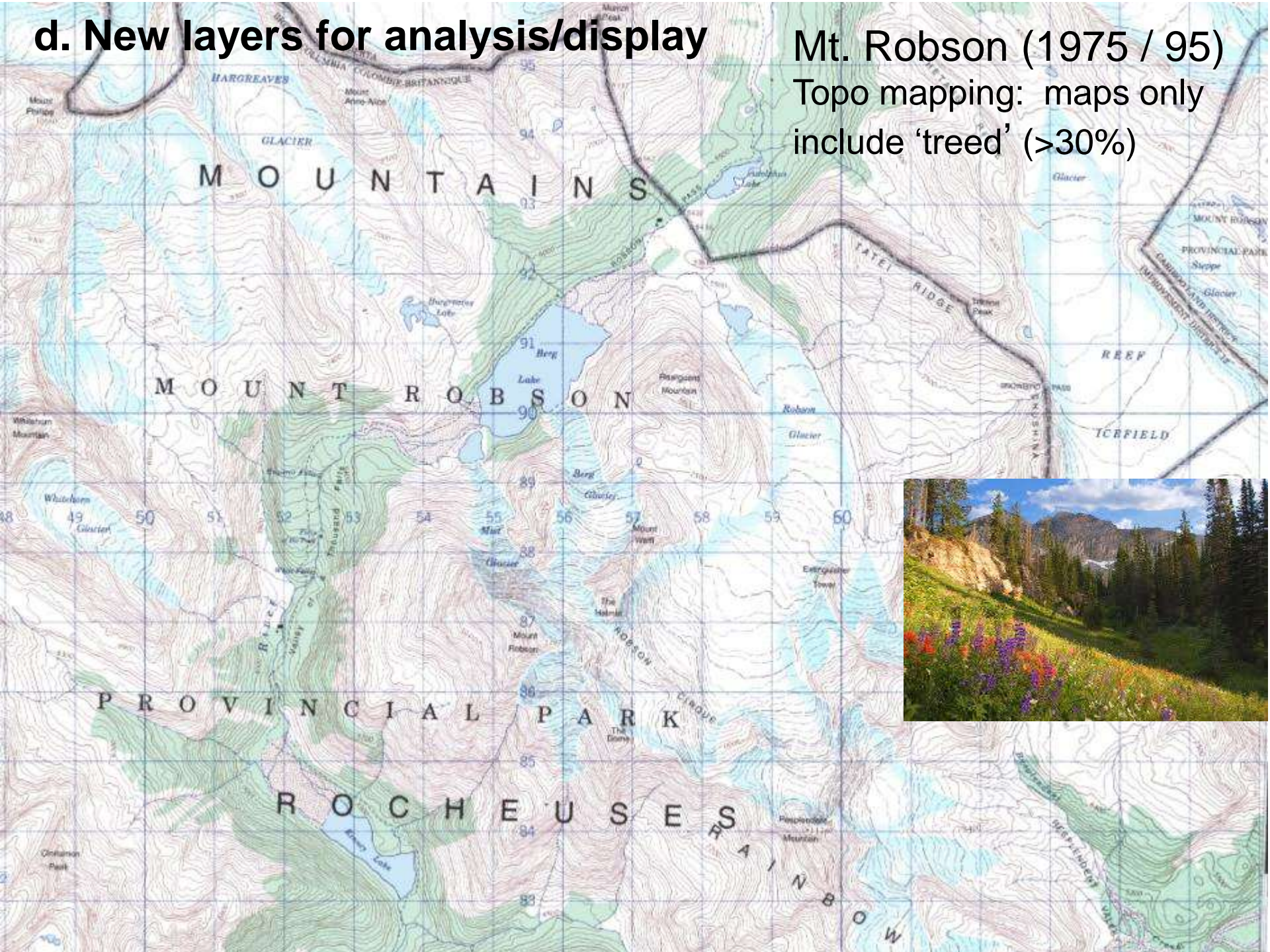
➤ **Use scalar multiplier ~10,000**

*Check channel histograms and stats first*

## d. New layers for analysis/display

Mt. Robson (1975 / 95)

Topo mapping: maps only include 'treed' (>30%)

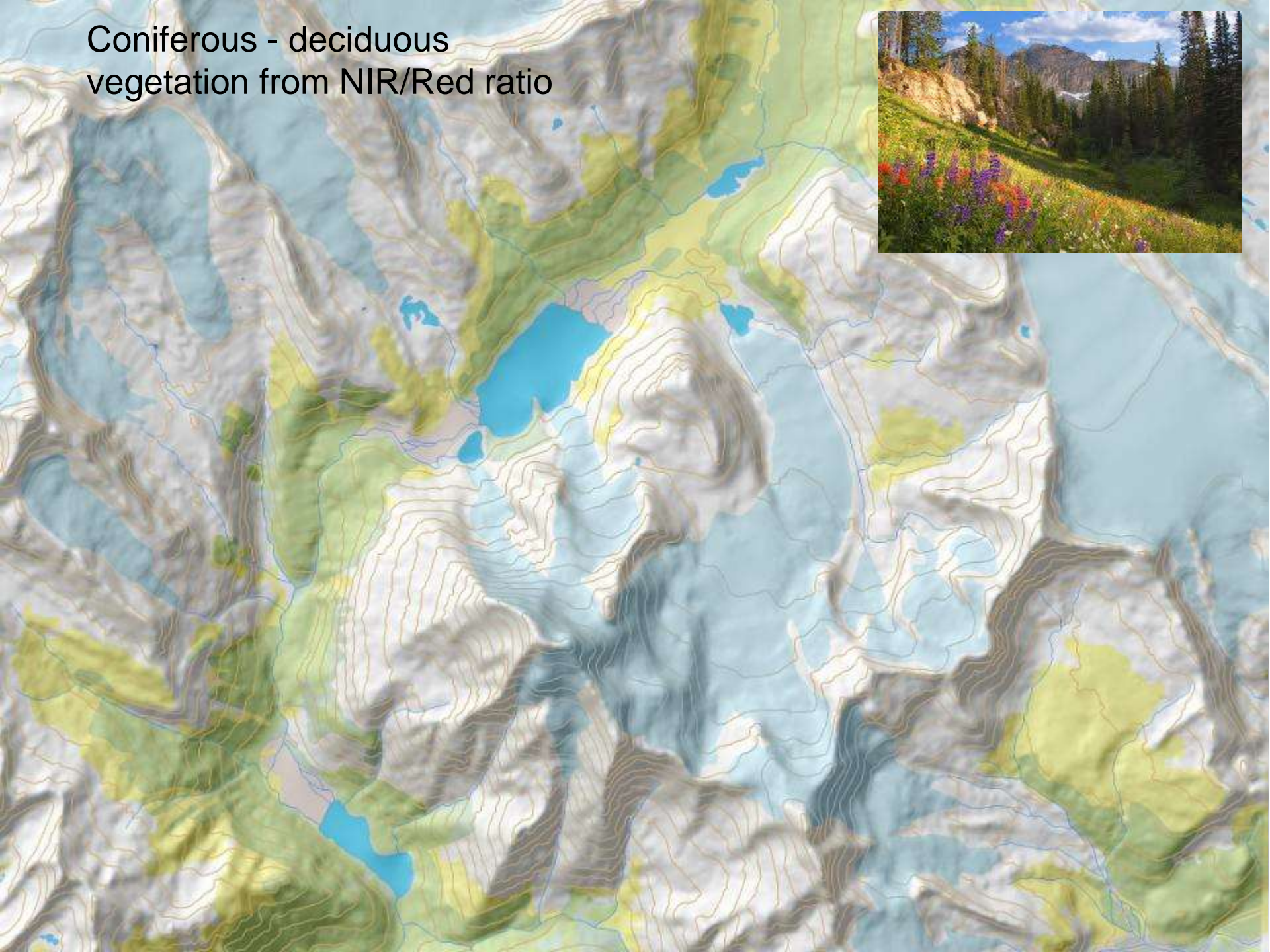




2015: forest and alpine vegetation can be easily seen as dark green vs yellow-green



Coniferous - deciduous  
vegetation from NIR/Red ratio



# Which other ratios might be useful?

Consider the bands and their place in the spectrum:

	Visible	/	IR	/	SWIR
TM	1,2,3		4		5,7
OLI	1,2,3,4		5		6,7

Ratios using **different EM sections** enhance **major class differences**, e.g. coniferous versus deciduous, rock versus vegetated (e.g. IR / Visible)

	SWIR / Visible		NIR / SWIR	
TM	7/3 lithology	3/5	snow and ice	4/5 Moisture
OLI	7/4	4/6		5/7

While pairs of bands from similar parts of the spectrum may show more 'noise' e.g. TM 2/3, 5/7, 3/1

# *Which other ratios could be useful?*

But there are applications using two bands in the same region,  
e.g. in geology

MSS: 5/4, 7/6      (4=green, 5=red, 6,7 =NIR)

TM: 3/2, 3/1, 5/7 :  
mineral enhancement (hydrothermally altered rocks)

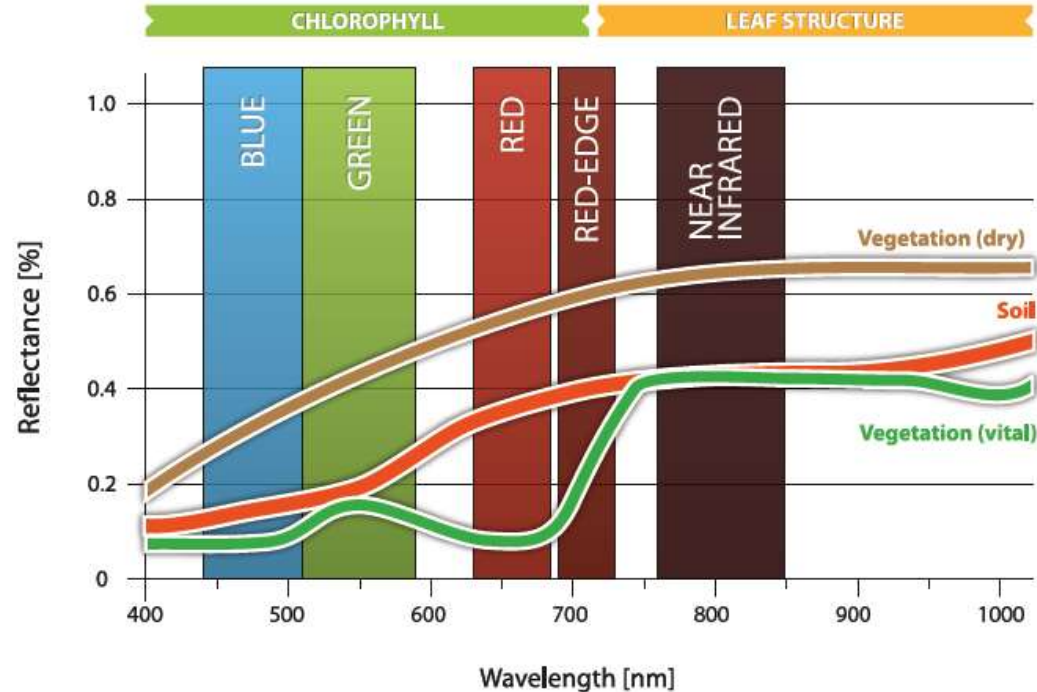
Ratio of two bands in the same EM region can distinguish  
**subtypes** such as soils, and geologic differences

Red-Edge Simple Ratio (**SRre**) = **NIR / RedEdge** 2008-> (Sentinel 2015->)

e.g. Sentinel 2 band 8 / 5 or ... band 8 / (band 5 + Band 6 + band 7)

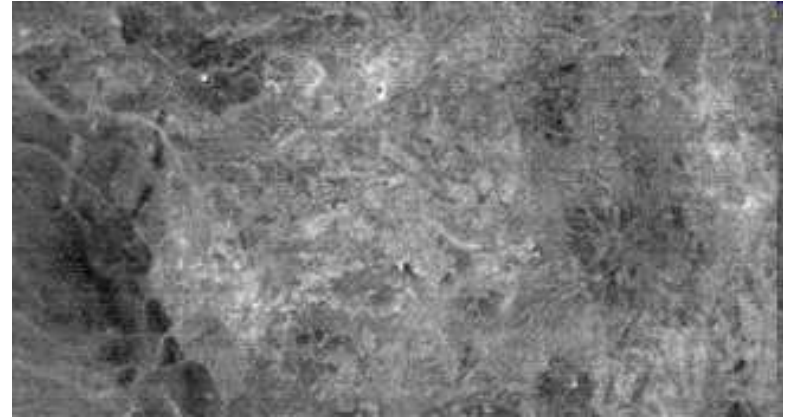
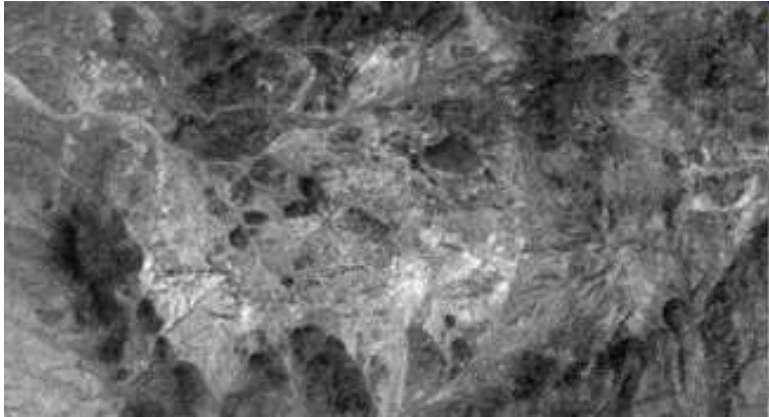
<https://pro.arcgis.com/en/pro-app/latest/arcpy/image-analyst/srre.htm>

The three 20m 'red edge' bands of Sentinel-2 (~670-780nm) multispectral instrument (MSI) provide key information on the state of vegetation.

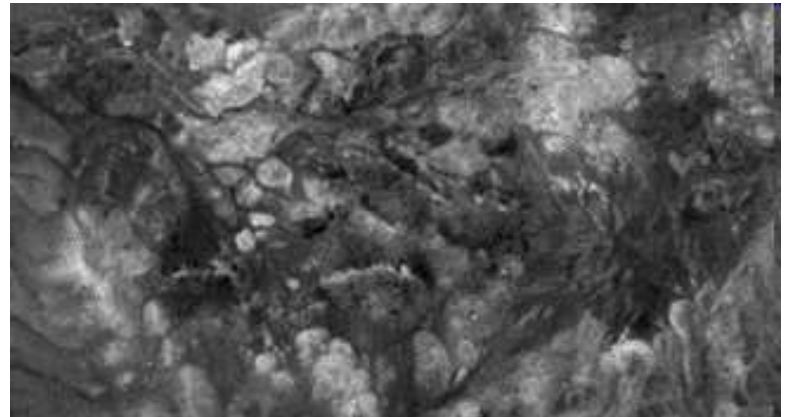
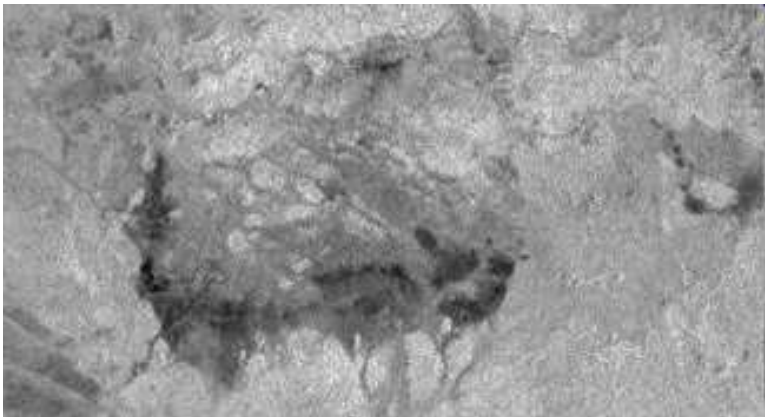


# Thematic Mapper ratios, Utah (desert scene)

ratios 3/1 and 4/2



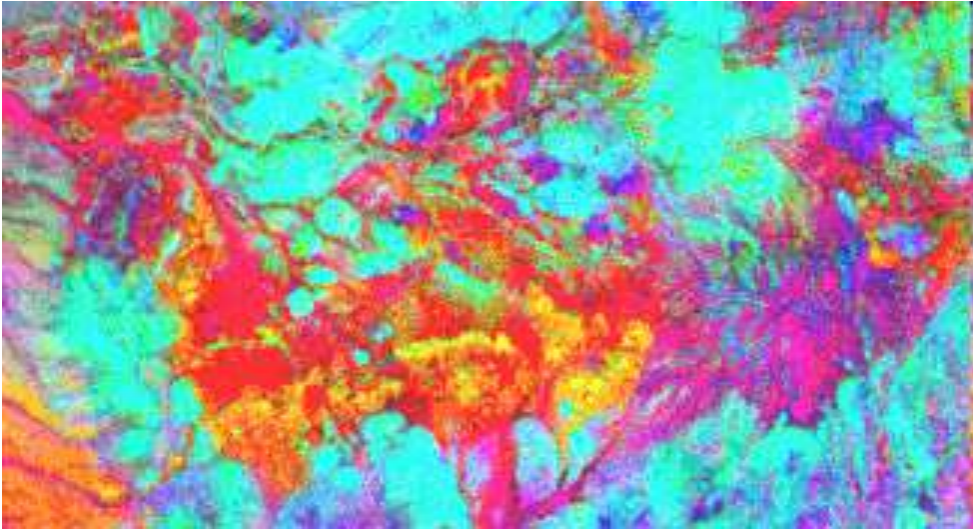
7/5 and 1/7 ratios



Geologists love these when there is no vegetation in the way ....

# Ratios: e. Creating Colour Composites

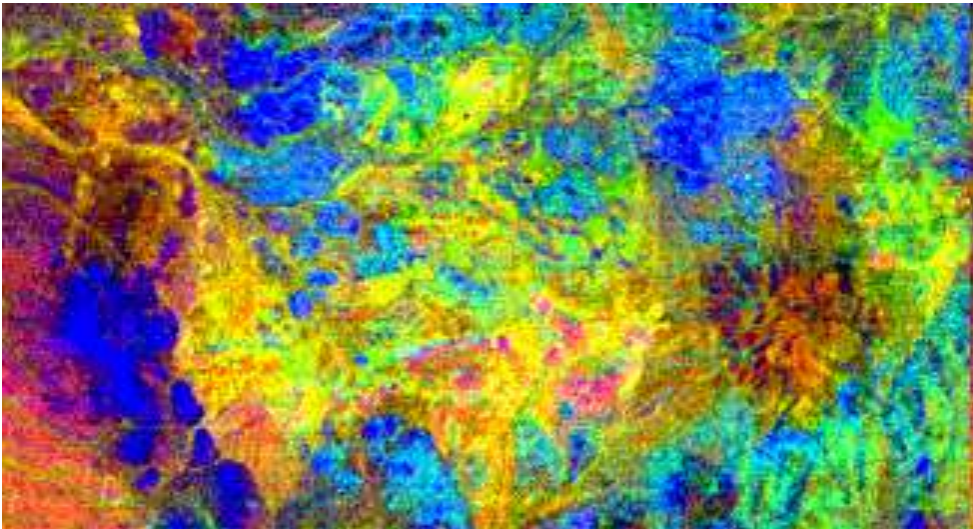
- use any 3 channels, not just bands



7/5 in Blue

1/7 in Green

3/1 in Red



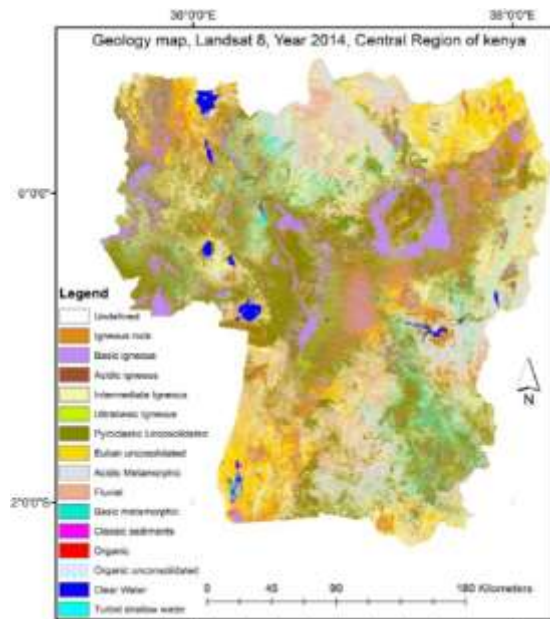
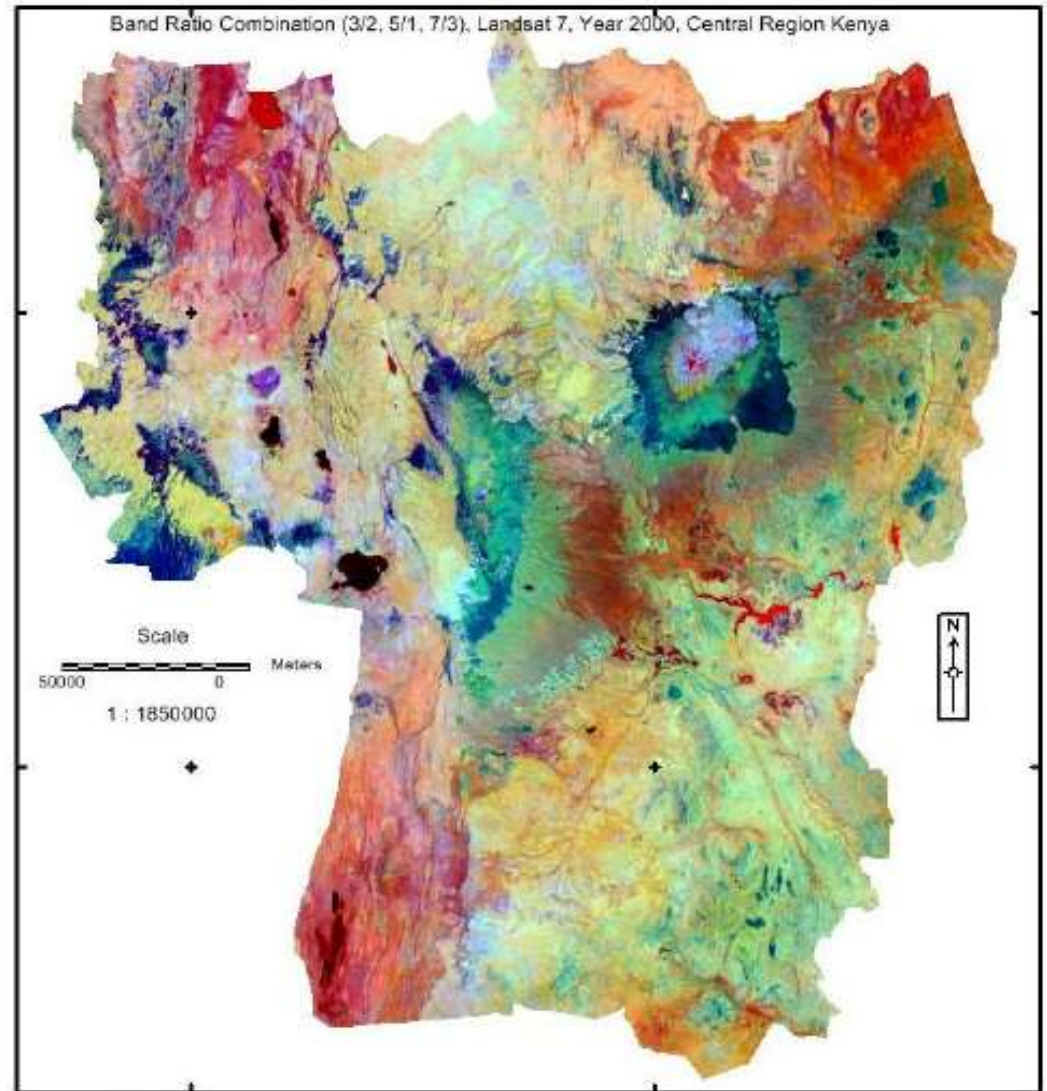
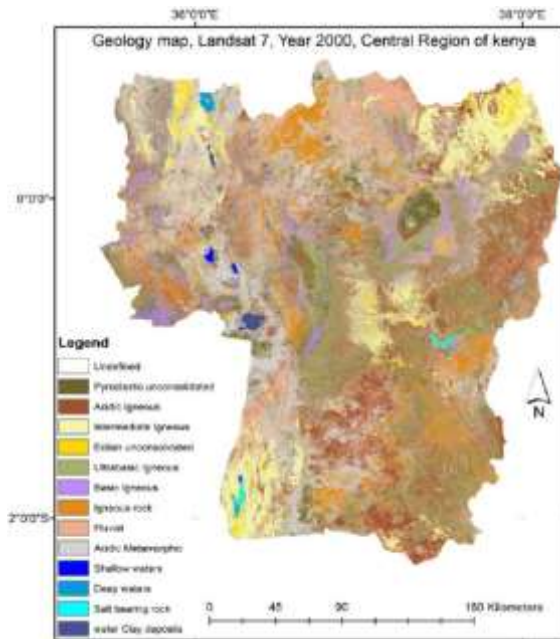
1/7 in Blue

4/2 in Green

3/1 in Red

How many possible colour composites are there from 15 ratios ? (15x14x13=2730)

# Band ratios



Band ratio combination (3/2, 5/1, 7/3), Landsat 7

# Other Image Arithmetic (tool: ARI)

also: RTR (ratios) and Raster Calculator

Band ratios are the result of 'division' /

it is also possible to use the other arithmetic operators:

## b. Band (image) subtraction -

Yields the difference between two bands; the result will include values that are + and - ..... requiring a 16 bit signed channel:

useful for showing changes through time with two image dates.

- More on this when we discuss change detection



## b. Band (image) multiplication

Used with a **mask**, where one layer is 1 or 0  
e.g. land or water ... your water bitmap in lab 2  
or forested vs non-forested in the EOSD Canada mapping project

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LAND-WATER MASKS: BASIS FOR  
AUTOMATED PRE- AND THEMATIC  
PROCESSING OF REMOTE SENSING  
DATA Erik Borg, Bernd Fichtelmann  
mapping project

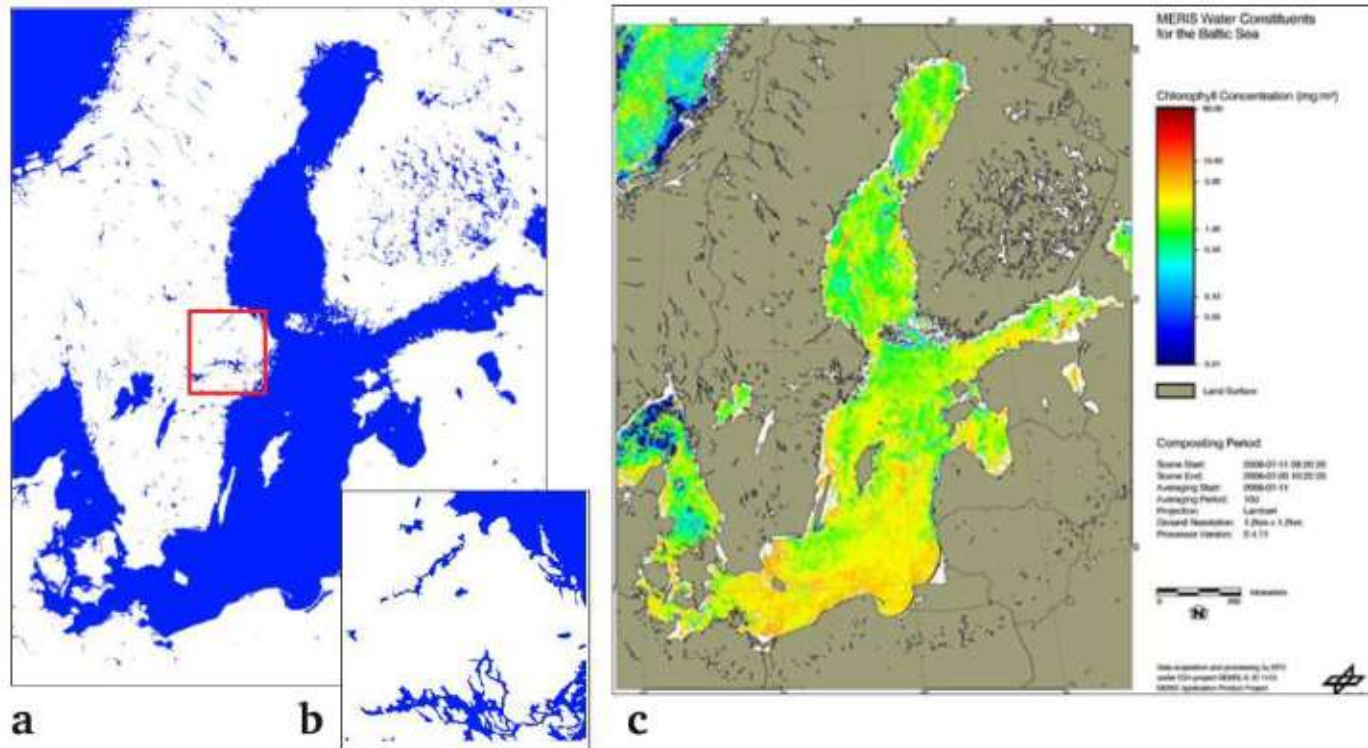


Figure 2: Land-water-mask of limited quality (a). The section shows details of the map around Stockholm (b). Quick-look product "Chlorophyll Concentration in the Baltic Sea" based on MOS data (c).

# Other Image Arithmetic

## c. Band (image) addition +

Used to create an overall or average image channel,

e.g.  $(TM1 + 2 + 3) / 3$  (= ~PAN ?) or  $SWIR = (TM5 + TM7) / 2$

An 'index' uses addition and subtraction (see next lecture)

<https://enterprise.arcgis.com/en/portal/10.7/use/band-arithmetic-function.htm>

How many possible colour composites are there from 15 ratios ?  
( $15 \times 14 \times 13 = 2730$ )

It doesn't end there - one could do ratios of ratios (  $15 \times 14$  options)

e.g.  $3/2 \div 5/1$  or even ratios of ratios of ratios:  $3/2 \div 5/1 \div 7/3$

Endless options, but what would they show ??

Sentinel 2 ratios and colour composites

<https://www.facebook.com/arabnubiagroup/videos/applying-different-band-ratio-composites-on-sentinel-2-imagery-which-equivalent-/2520705917991385/>

<https://www.facebook.com/arabnubiagroup/videos/applying-band-ratios-on-sentinel-2a-multi-spectral-satellite-imagery-could-be-ve/1344438065690657/>