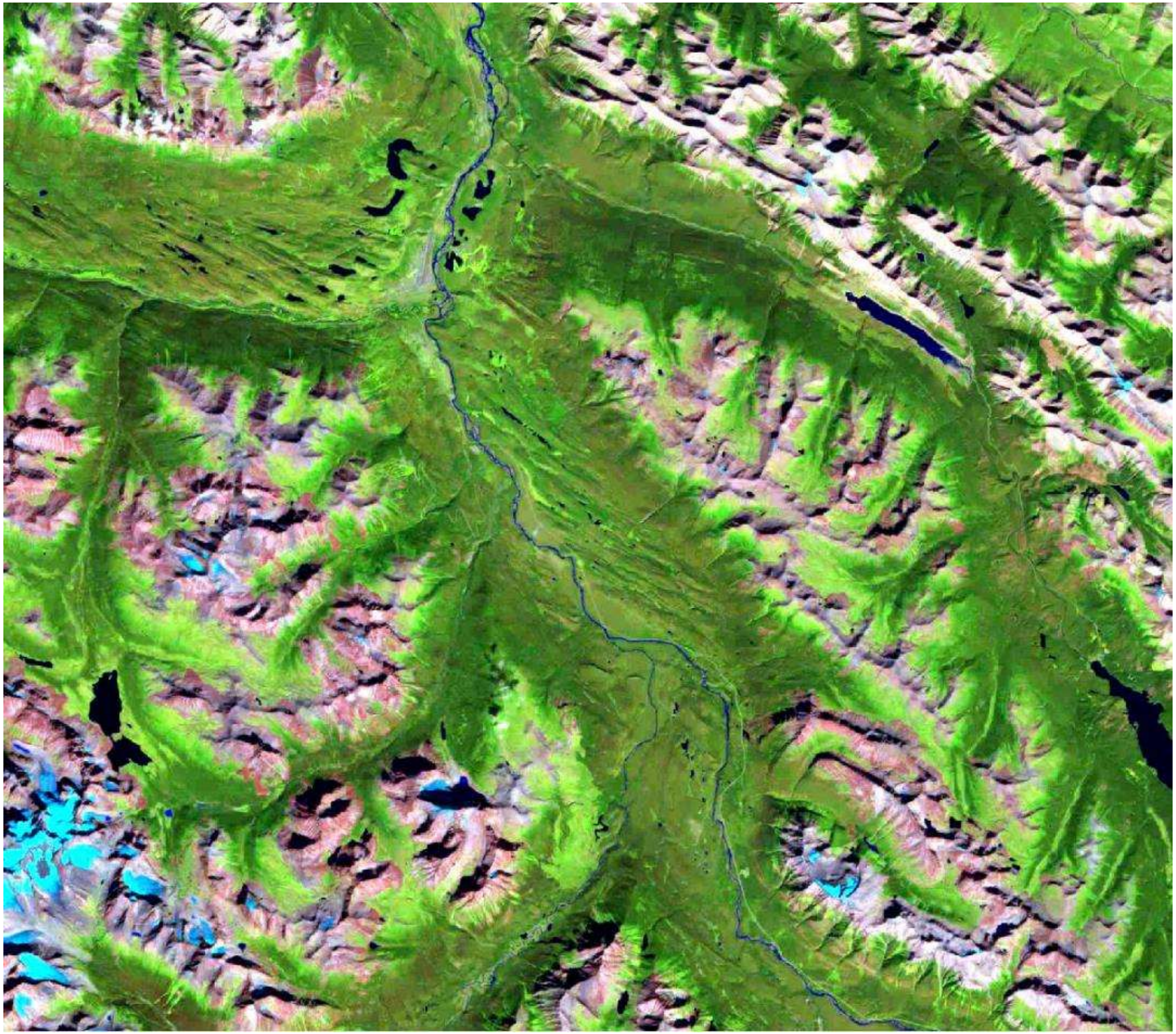
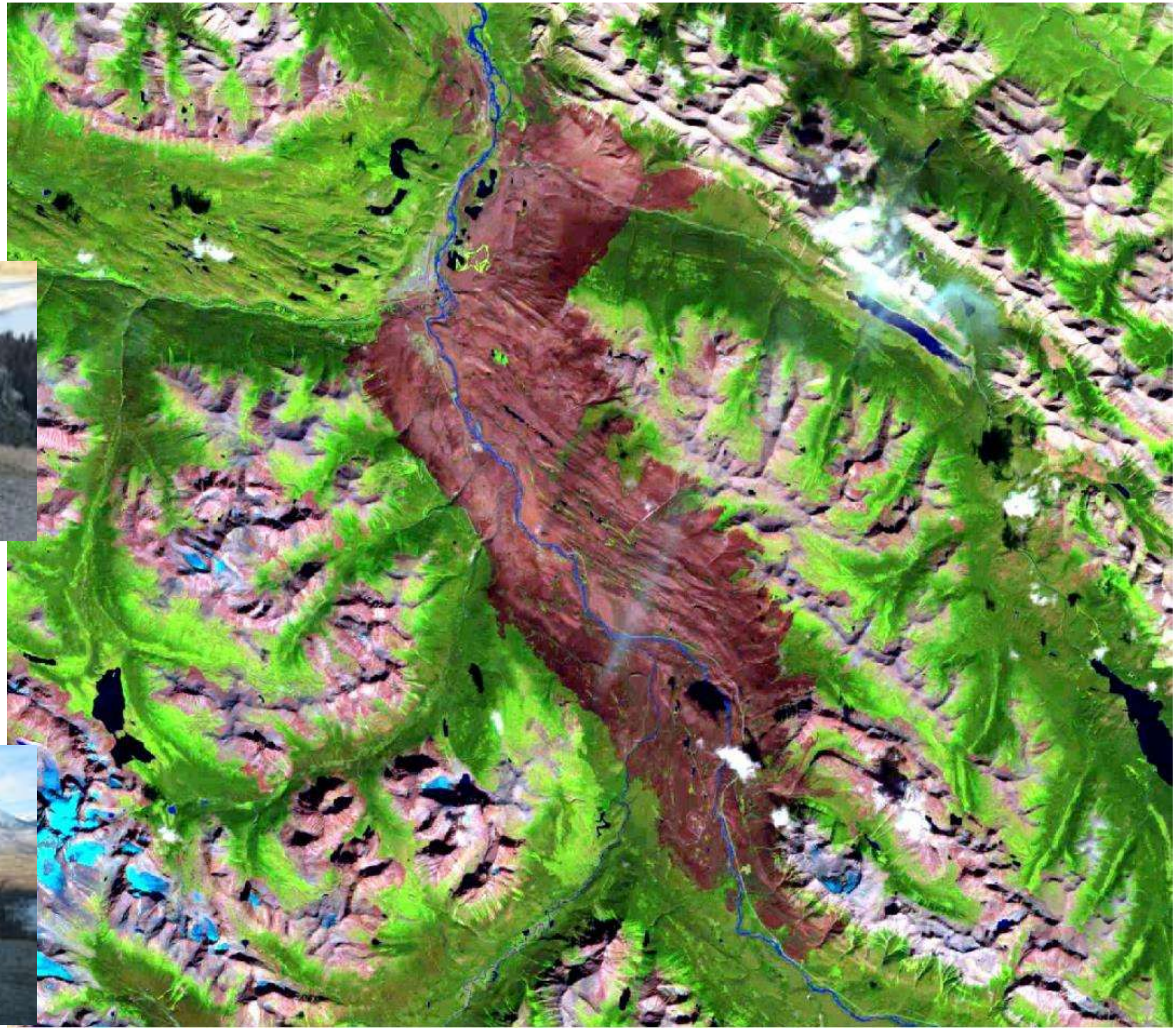
Change Detection

Jasper pre-fire
Sept 2, 2023
Landsat 8 OLI
Path/row 45-23

Perfect registration, due to correction using 30m DEM (since ~2010) – previously up to 6 pixels misalignment



Jasper post-fire
Aug 19, 2024
Path/row 45-23
Landsat 9 OLI-2



Old Fort Point- unburnt grassy hill in upper centre; below with Bighorn sheep, females

Change detection

.. Using repeat images from different time periods

1. Display: side by side or slider or sequence (animation)

2. Display: digitise features / overlay

3. Digital analysis algorithms

a. Simultaneous display

b. Image algebra (notably subtraction)

c. Classification (multiple)

Example from Landsat 5

Landsat program (since 1972 / 1984)

Satellite imagery

- Minimal distortion
- Similar time of day =~ consistent lighting
- Consistent scale
- Multispectral data
- Calibrated system

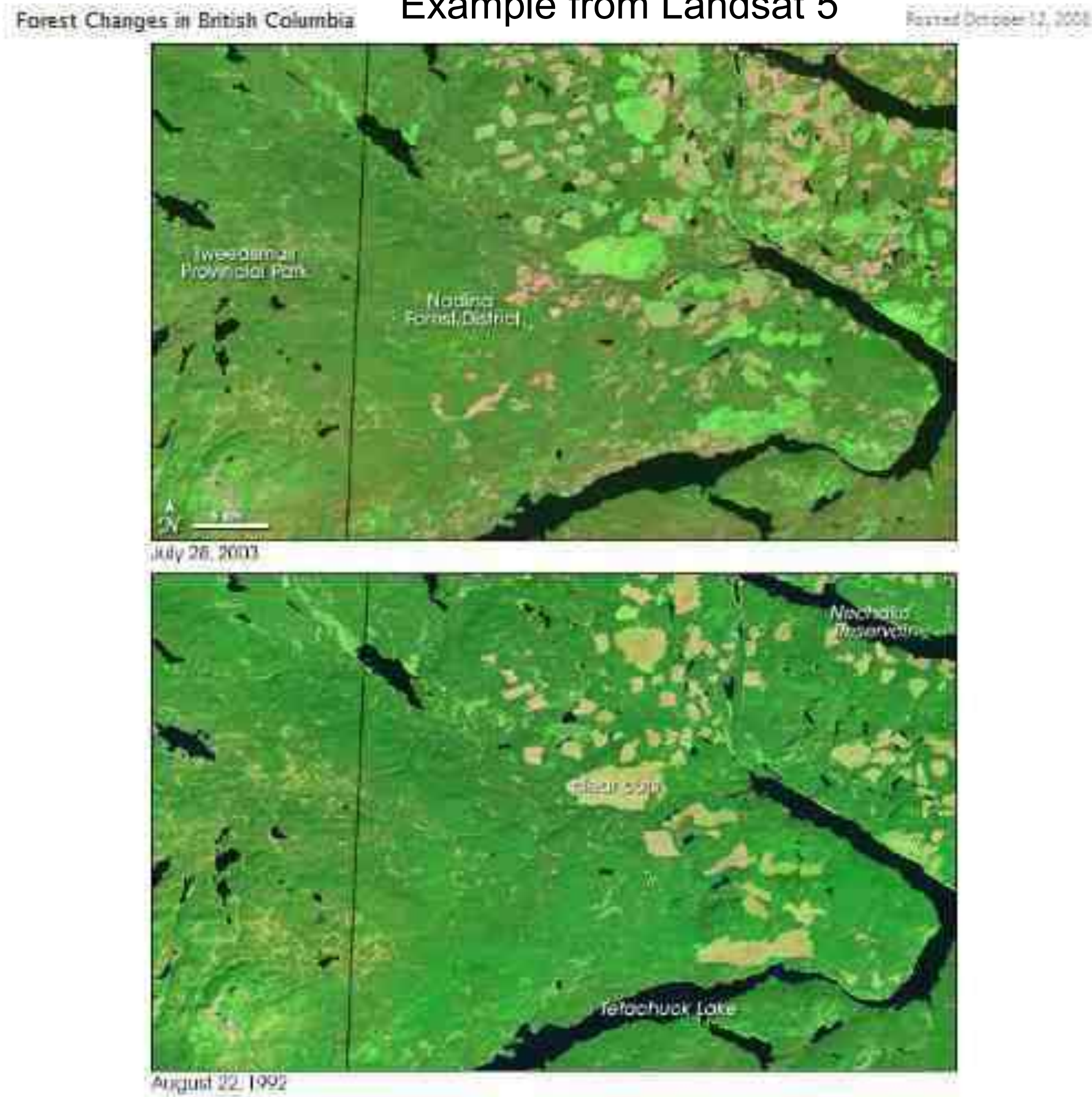


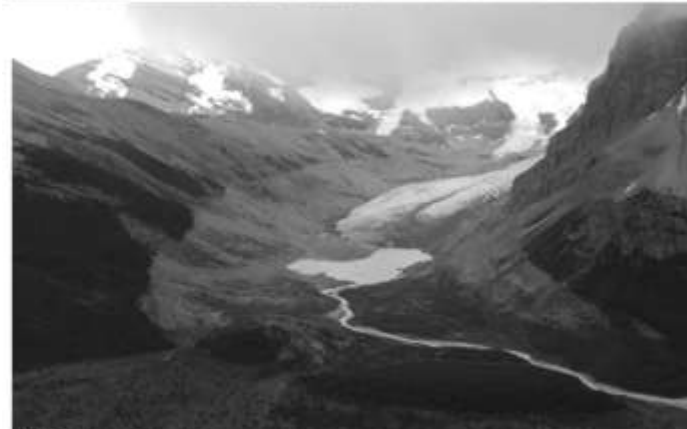
Image sequences for change

Ground photos/balloons	1850 ->
Air photos	1920 ->
Landsat MSS (80m)	1972 -> 1992 -> (2012)
Landsat 4-9 (TM->ETM+ -> OLI)	1984 -> 2002-> 2013/2022->
AVHRR (1km) NDVI	1979 ->
High resolution (1 m)	2000 ->
ASTER / MODIS	2000->
Sentinel 2	2015 ->

1911 Photo: Whyte Museum of the Canadian Rockies (V263/NA 6345, Byron Harmon)

2025 Photo: Matthew Beedle

1911 Photo: Whyte Museum of the Canadian Rockies (V263/ NA 6345, Byron Harmon)



2011 Photo: Roger Wheate

2025 Photo: Matthew Beedle

Change monitoring Considerations 1

Timing (day/season)

- Time of <u>day</u> affects horizontal sun angle (azimuth)
  … it is consistent with most satellites e.g. Landsats, Sentinels

- Time of <u>year</u> affects vertical sun angle /shadow (zenith)

- Seasonal ground cover – vegetation, snow, crops

- Image data should be collected ‘near’ <u>Anniversary</u> Dates

- Seasonal phenology – varies by up to 2 weeks before/after

- If these are not matched, you may see ‘non-real changes’


WOLVERINE
May 13, 2022


WOLVERINE
May 13, 2016

Change monitoring considerations 2

Frequency / type of Changes

- short term versus long term e.g. lakes v reservoirs, snow v glaciers
- local versus global e.g. mining v arctic ice, desertification
- gradual versus catastrophic e.g. soil slip v landslide
- cyclical / seasonal changes – urban, agricultural and forest
- Weather is NOT interesting and clouds are the enemy

Digital Numbers may be composed of three elements:

a. Atmospheric interference (e.g. haze, clouds)

b. Illumination (angle of reflection)

c. Albedo (response to surface cover)

Change monitoring considerations 3: resolution

Spatial resolution: Pixel size: Good registration is critical

Radiometric Resolution: Range / precision of digital numbers e.g. 8 bit v 16 bit

Temporal resolution: Time of day and interval between images

- Image data should be acquired the Same Time of Day (most satellites)
- Image data should be collected near Anniversary Dates

*What happens to **Digital Numbers** if sun angle is lower ?? Answer: ?*

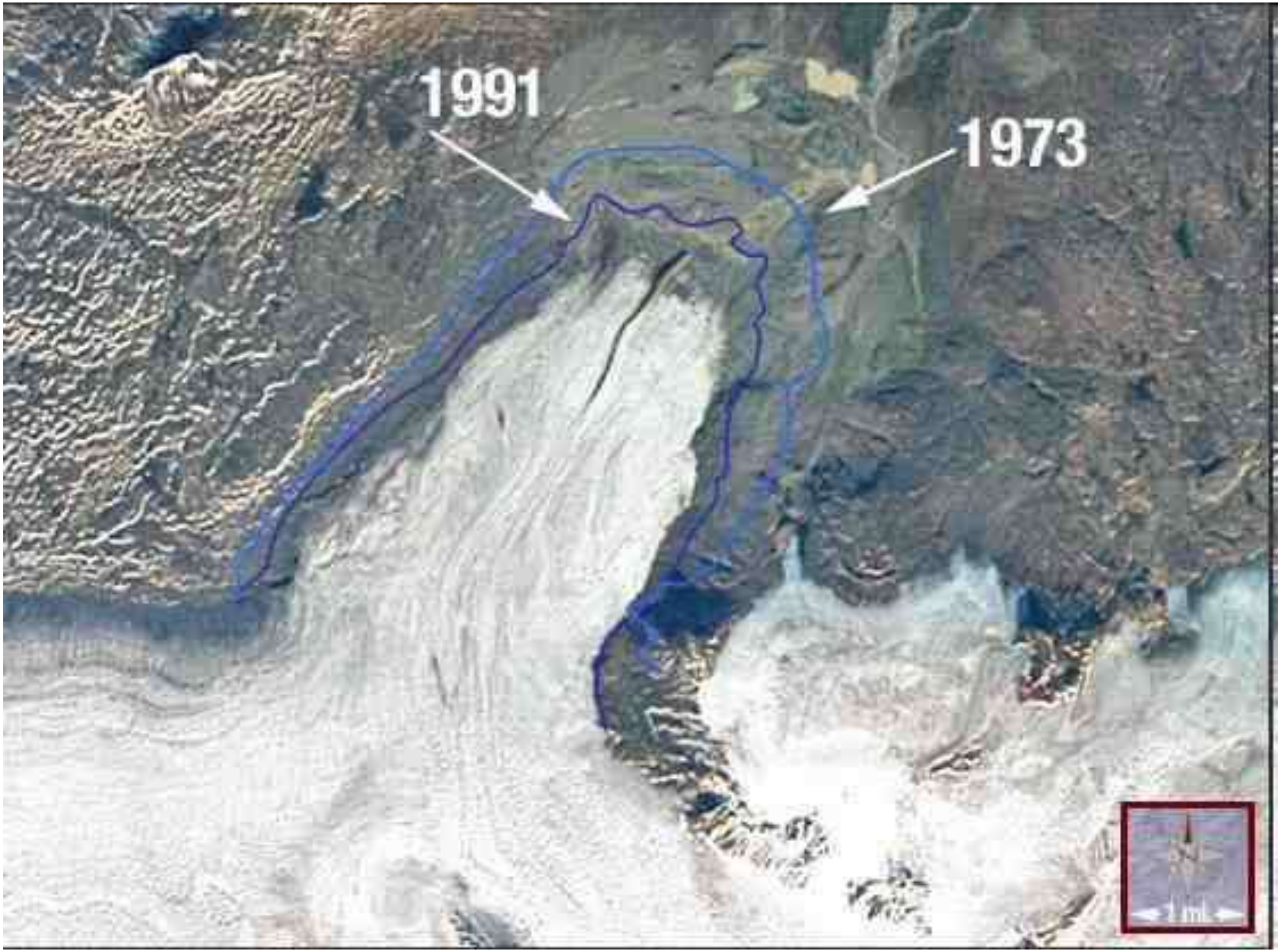
Spectral resolution: Same wavelengths range
e.g. Landsat TM IR bands are not the same as L8/9 OLI or SPOT IR bands

These may impact visual comparisons of RGB composites, but are critical for digital analysis methods

1. Side by side / slider

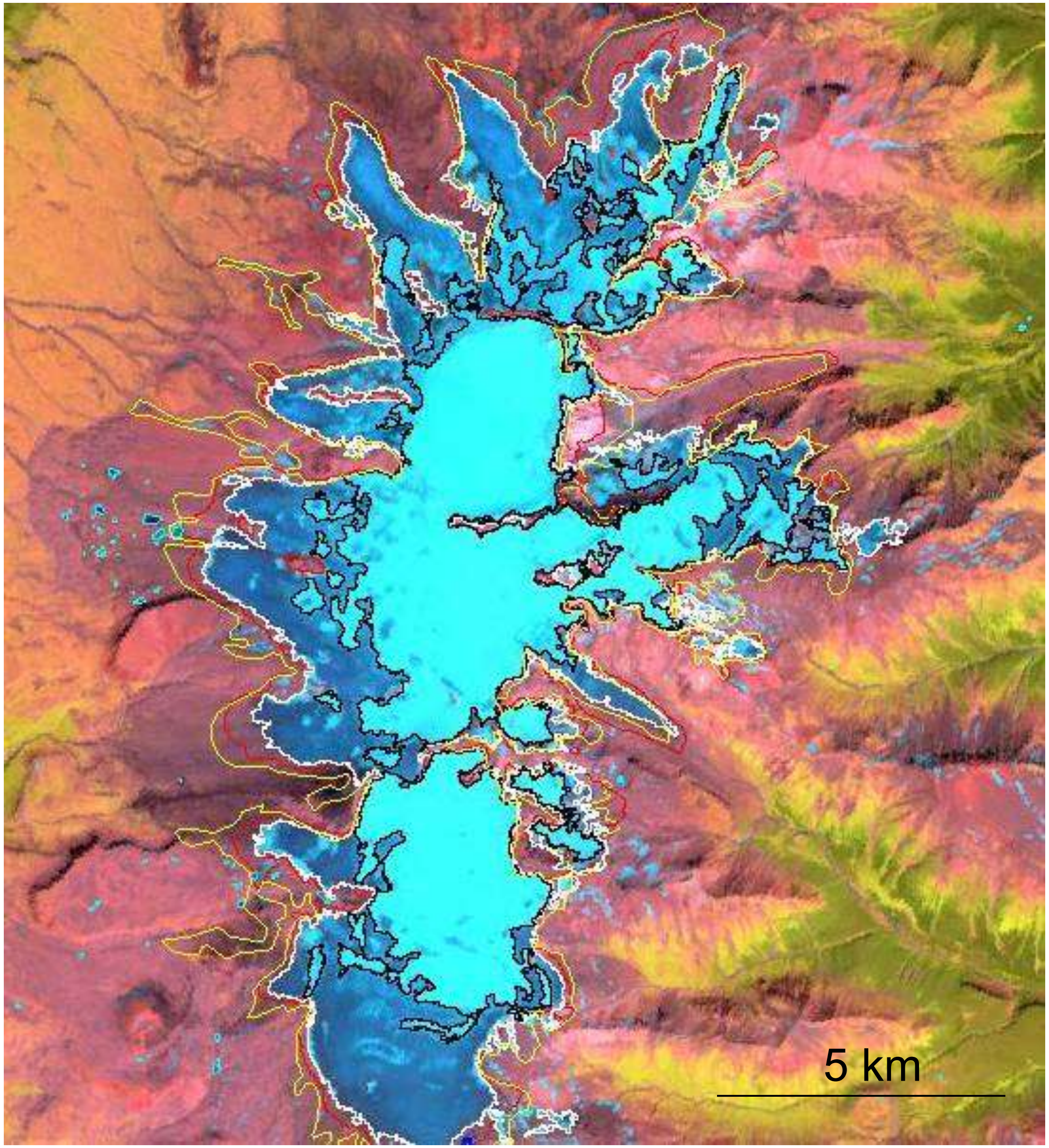
https://earthobservatory.nasa.gov/images/151622/canals-in-ukraine-are-drying-up

2. Digitised / extracted features: Eyjabakkajökull, Iceland



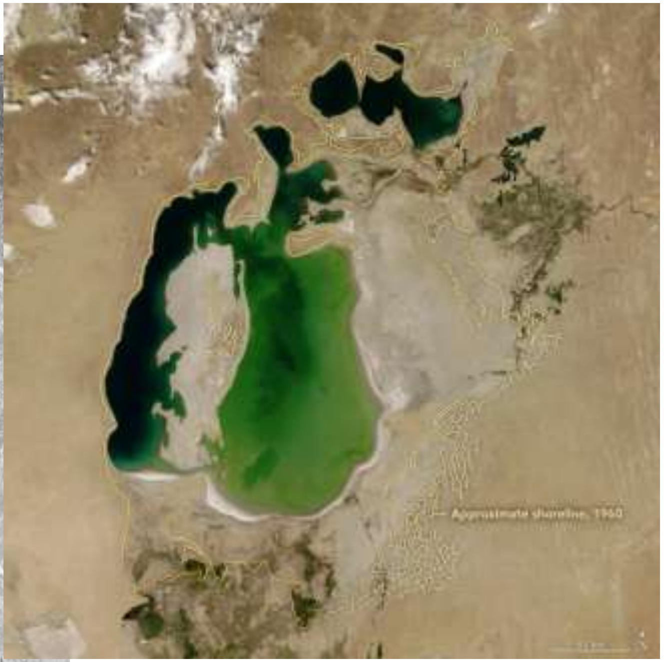
Generated from maps, digital vectors, or image processing – all initially remote sensing

Edziza: extents from federal NTDB 66, BC provincial TRIM 85, Landsat 2000



Animation / Digitising : Aral Sea (Kazakhstan / Uzbekistan)

http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php MODIS 2000-2018



Aral Sea 1964 from spy satellite

See also maps.google.ca - streetview

3. **Digital algorithms**

Digital analysis for change over time can operate on:

- a. **Individual bands** (a bit uncommon)
- b. **Image channels** e.g. Ratios, NDVI, Tassel Cap
- **c. Classified images**

Digital algorithms
1. simultaneous display - RGB

Display the same band from three different dates in RGB.

Date 1: Blue gun

Date 2: Green gun

Date 3: Red gun

Three images, one in each of RGB, no change = gray.
(DN1=DN2=DN3)

Increase in reflection = higher DN = e.g. more red
(colour scheme could be reversed if suitable)

3a. simultaneous display - RGB

Prince George (band 3-Red DNs for 3 years):

2003 (B) July 22

2004 (G) Aug 9

2005 (R) Aug 19

Impact of reflection change

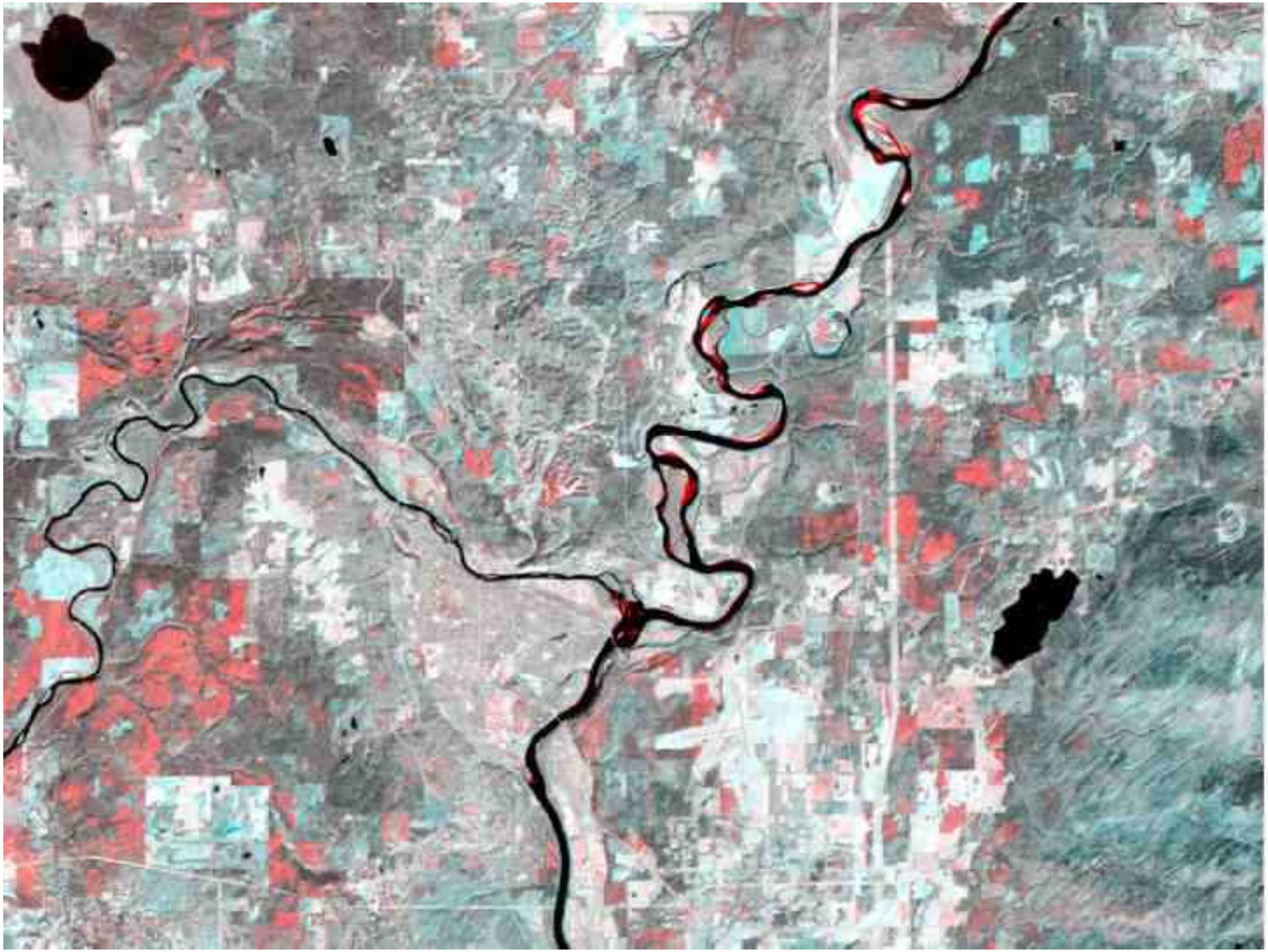
Increase = more red (Areas cleared)

Decrease = blue (regrowth)

No change = grayish

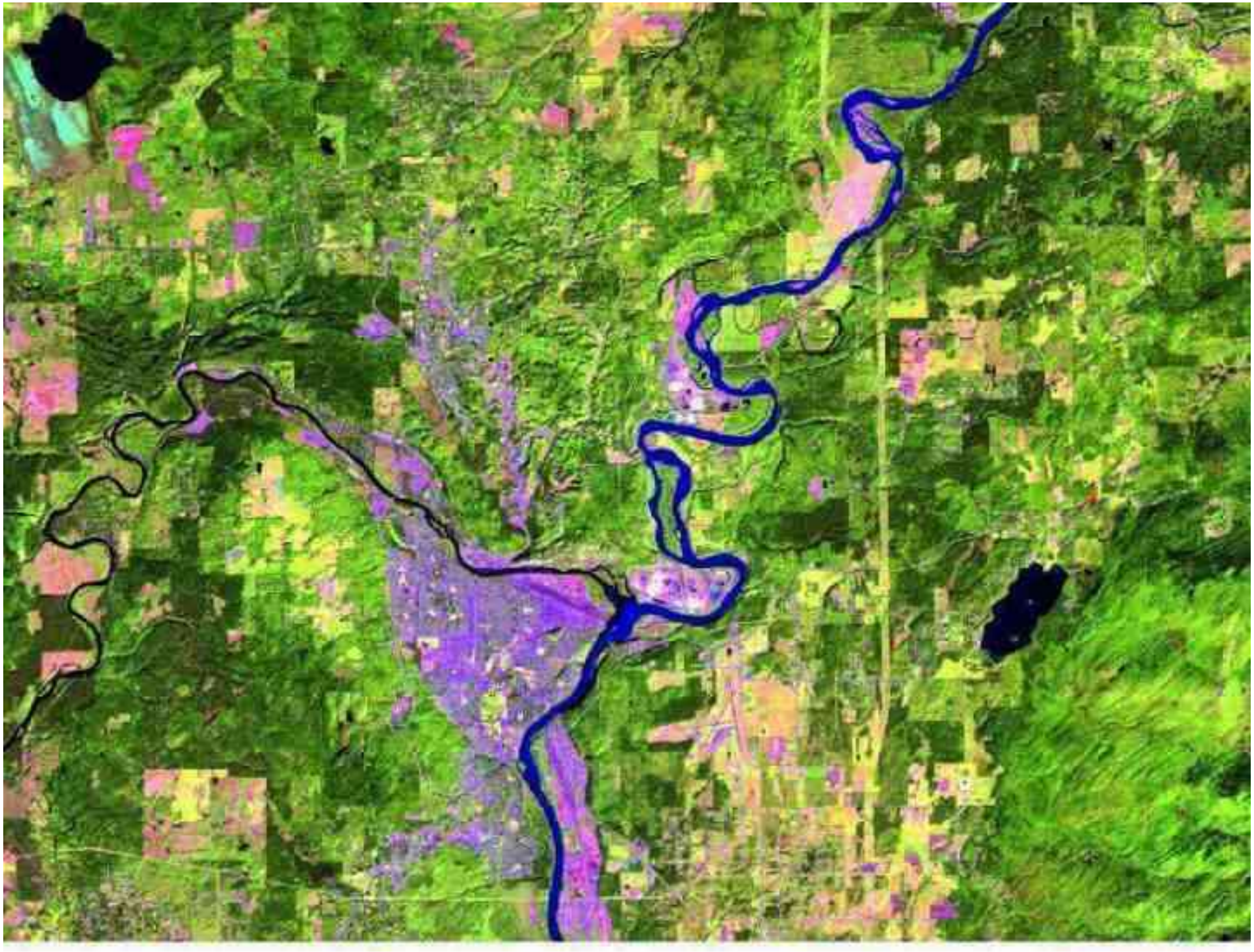
Seasonal: fields, river

Easier with only two dates, project one in R, the other in G and B (or 0 in G)

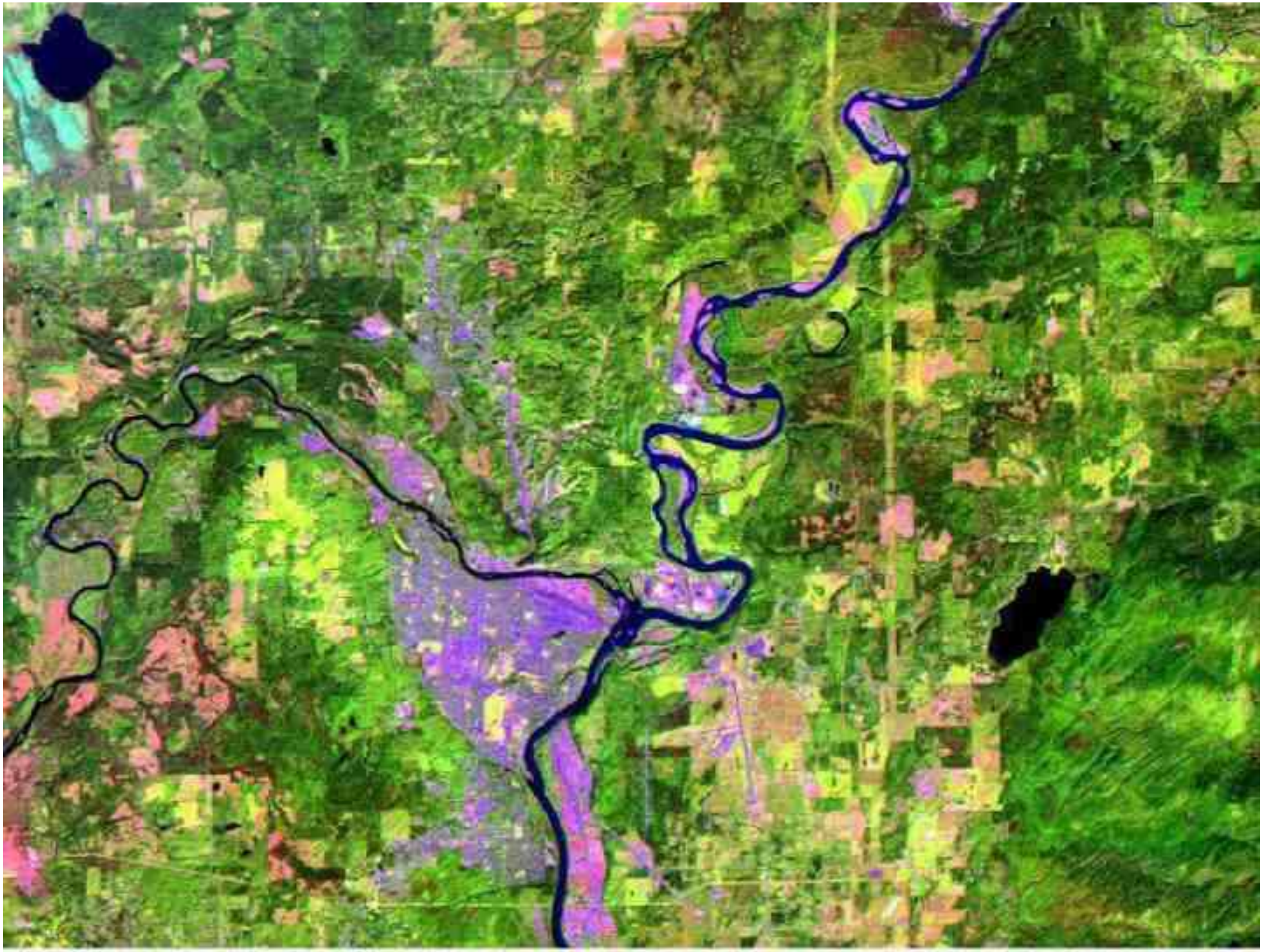


Band 5 (SWIR1), 2011 in red, 1996 in blue/green

PG image 1996



PG image 2011



Impact of forest clearance on bands

Visible: DN values <u>increase</u>

bare ground appears ‘brighter’ (initially)

NIR: DN values <u>decrease</u>

= less ‘healthy’ vegetation (initially) but quickly rebounds

SWIR: DN Values <u>increase</u>

= moisture decreases (soil and vegetation) – dryness increases

TIR: depends on time of day and season

see thermal lecture – hotter during the day / colder at night

Dubai has the world's largest artificial island, Palm Jumeirah, shaped like a palm tree and adds close to 50 miles to the city's coastline. The island is packed with luxury hotels, beachfront villas, and apartments.

Dubai Landsat 5 TM image, 543 RGB

August 24, 2001

Dubai Landsat 5 TM image, 543 RGB

August 23, 2017

Simultaneous display band 3 for 2000 (red) and 2006 (blue-green) – Dubai
* Different dates to the two previous images / and Red gun is used for later image

DN response to change will depend on which band is used e.g. visible v Near-IR

2. Image algebra - differencing

Subtract DN values (same band) date A – date B

More complex than it sounds: No change = ~ 0 Change = +ve or –ve

Evaluate meaning of + versus - (threshold / 16 bit signed channel)

Many reasons for variation (e.g. weather, haze, season etc..)

Need to convert if the datasets are 8 bit and 16 bit

But which band(s) to choose ?

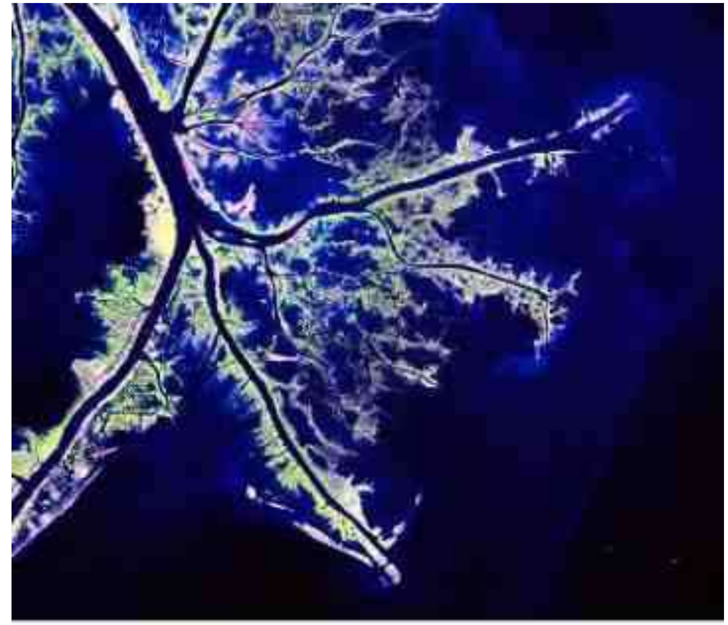
Bands need to have similar mean / std.dev to compare

and what about other changes (e.g. haze adds to DN) – need to <u>normalize</u>

There are fewer issues using differences in ratios, **indices** (normalised) and components e.g. **tasseled cap**

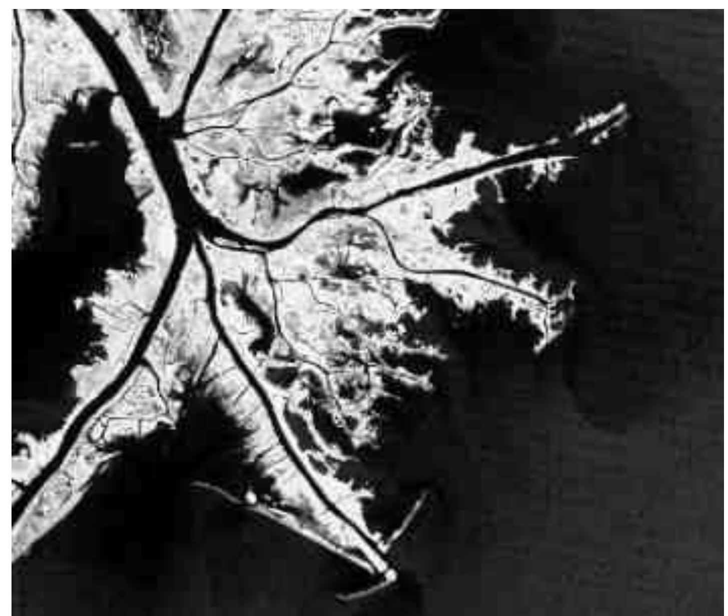
Mississippi Delta: TM543 in RGB: 2004, 2005, 2010 (Hurricane Katrina, Aug 2005)
Colour composites for before / after / regrowth

2004



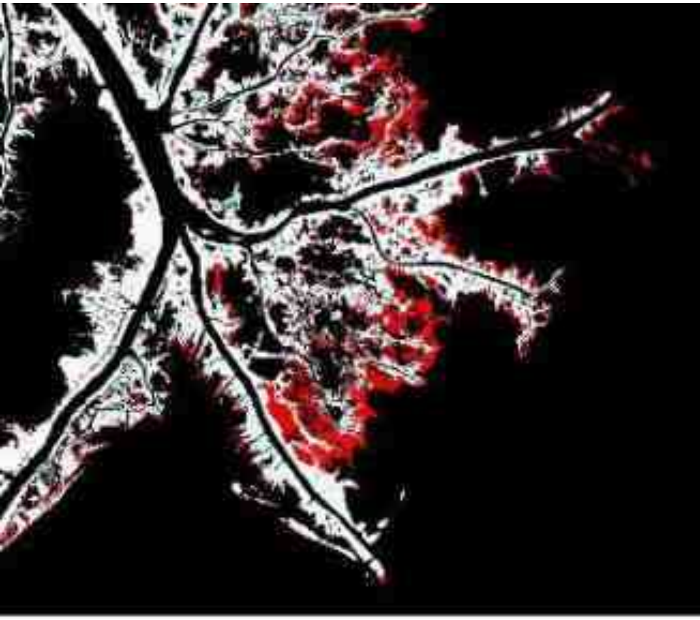
2005

2010

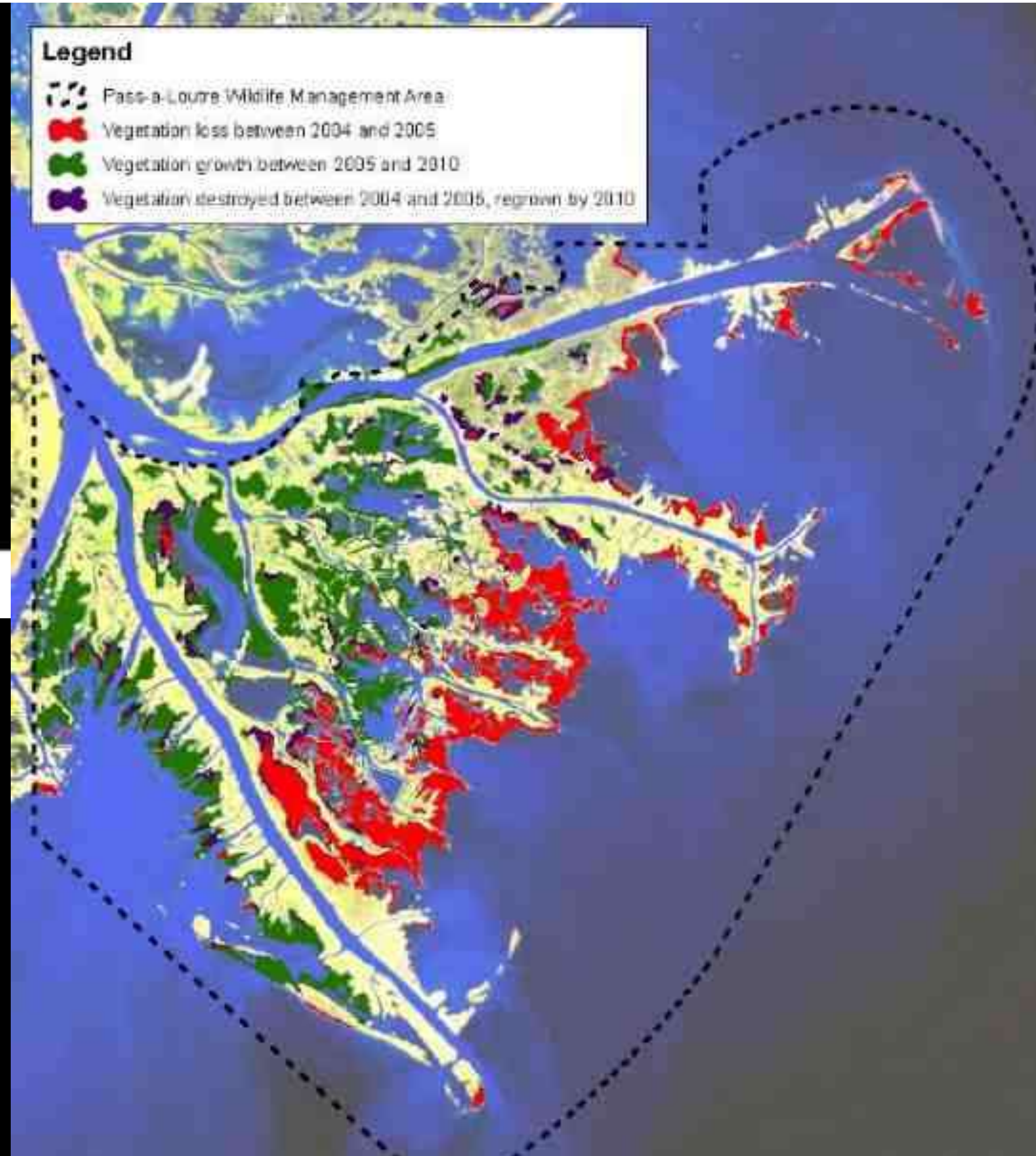


NDVI
2010

NDVI difference 2004-5

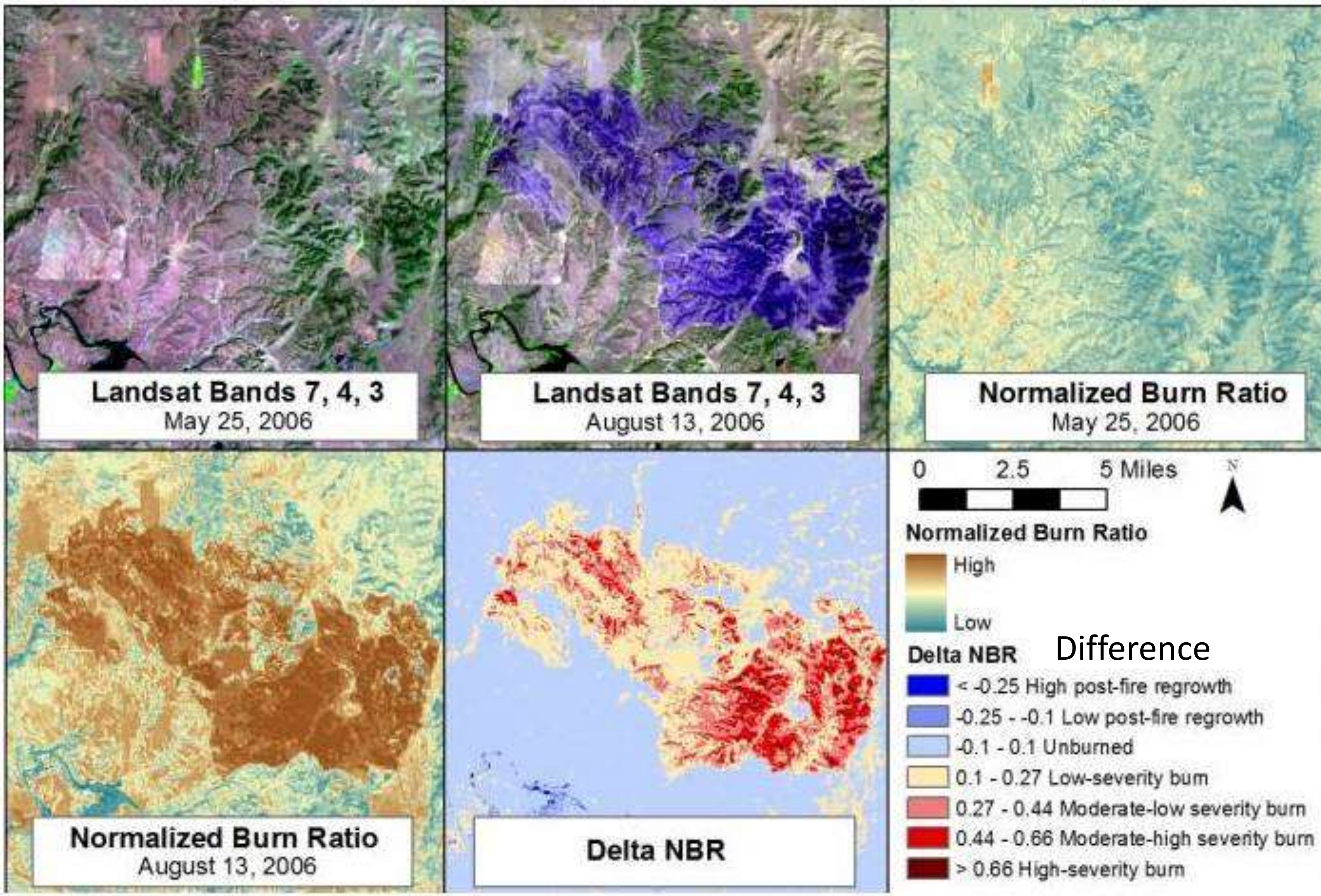


NDVI difference 2005-10



Normalised Burn Ratio (Index) : difference can give fires intensity, not just extent

(Near IR – SWIR2) / (Near IR + SWIR2) Landsat TM: NBR = (4-7) / (4+ 7)



Why NBR uses Bands NIR and SWIR2
Landsat TM bands 4 and 7
(OLI Bands 5 and 7)

$$\text{NBR} = \frac{NIR - SWIR}{NIR + SWIR}$$

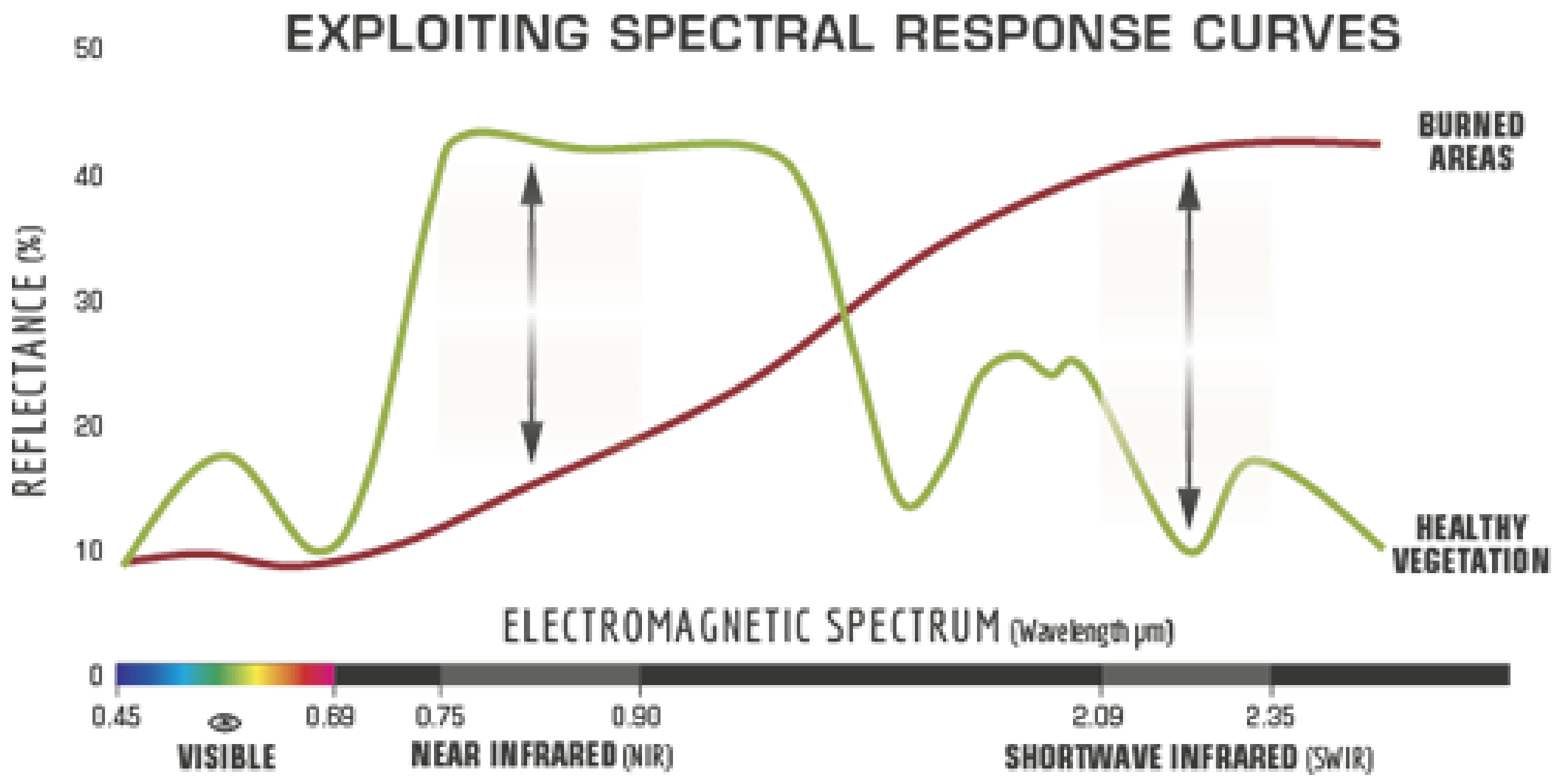


Image processing algorithms

3. Classification: areas produced by supervised classification, 2000

Edziza Park / Glacier

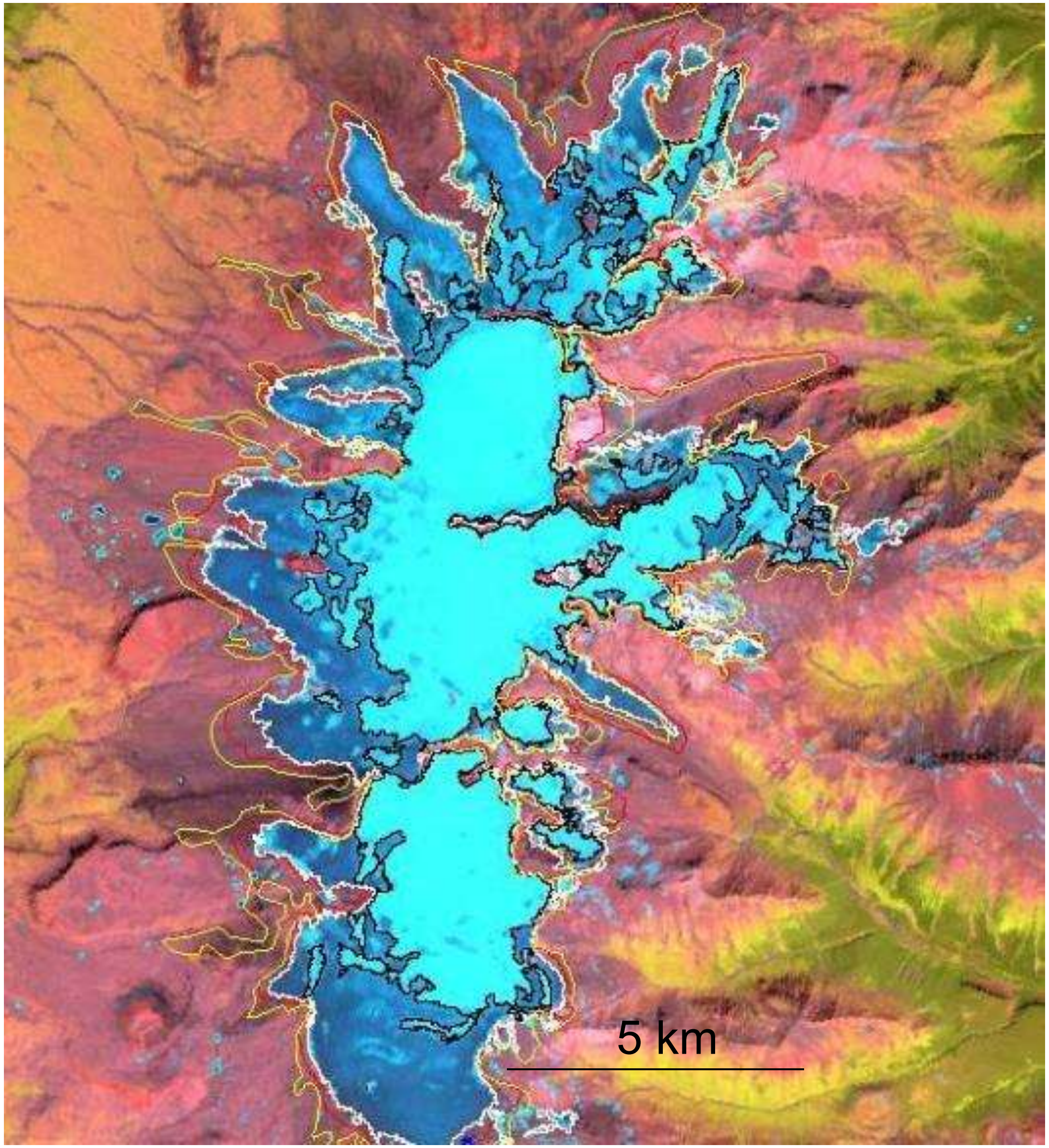
Vector extents

NTDB 1966 (yellow)

BC TRIM 1985 (red)

Landsat 2000 (white / black)

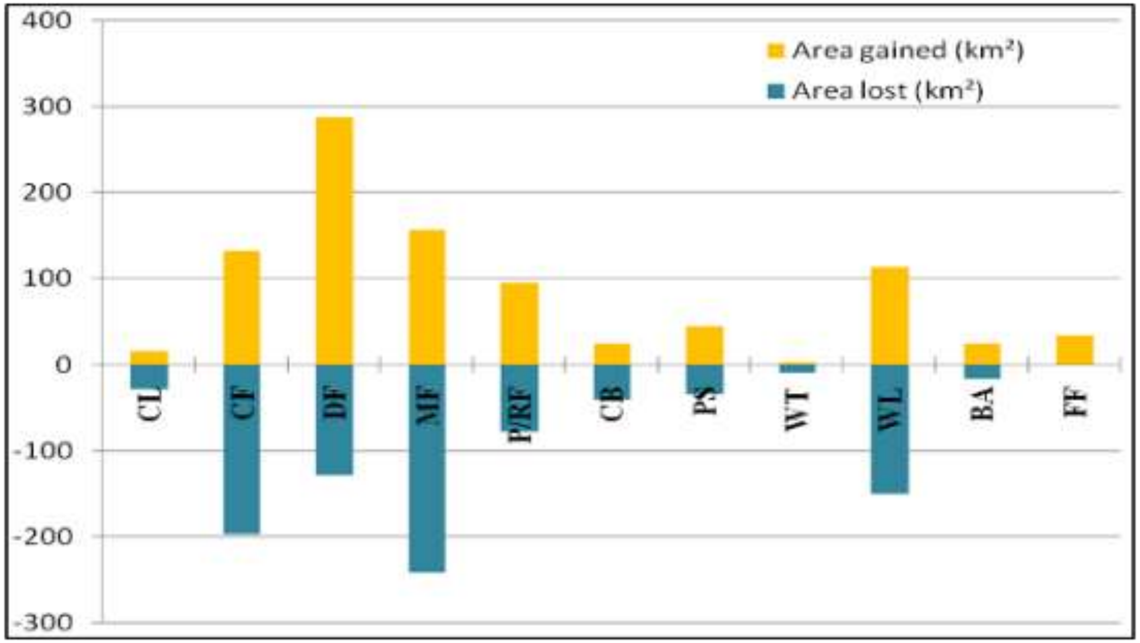
Training on accumulation / ablation areas



UNBC M.Sc thesis – supervised classifications 1984 and 2010

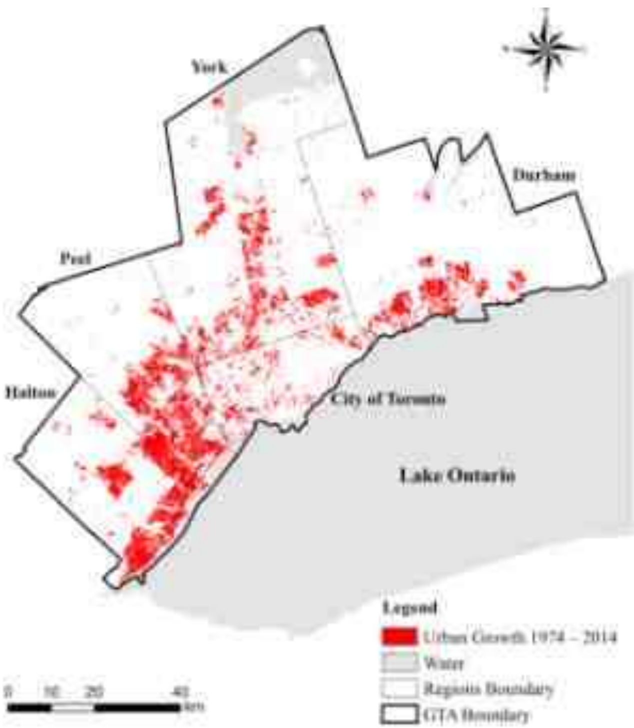
Watershed SW of Vanderhoof

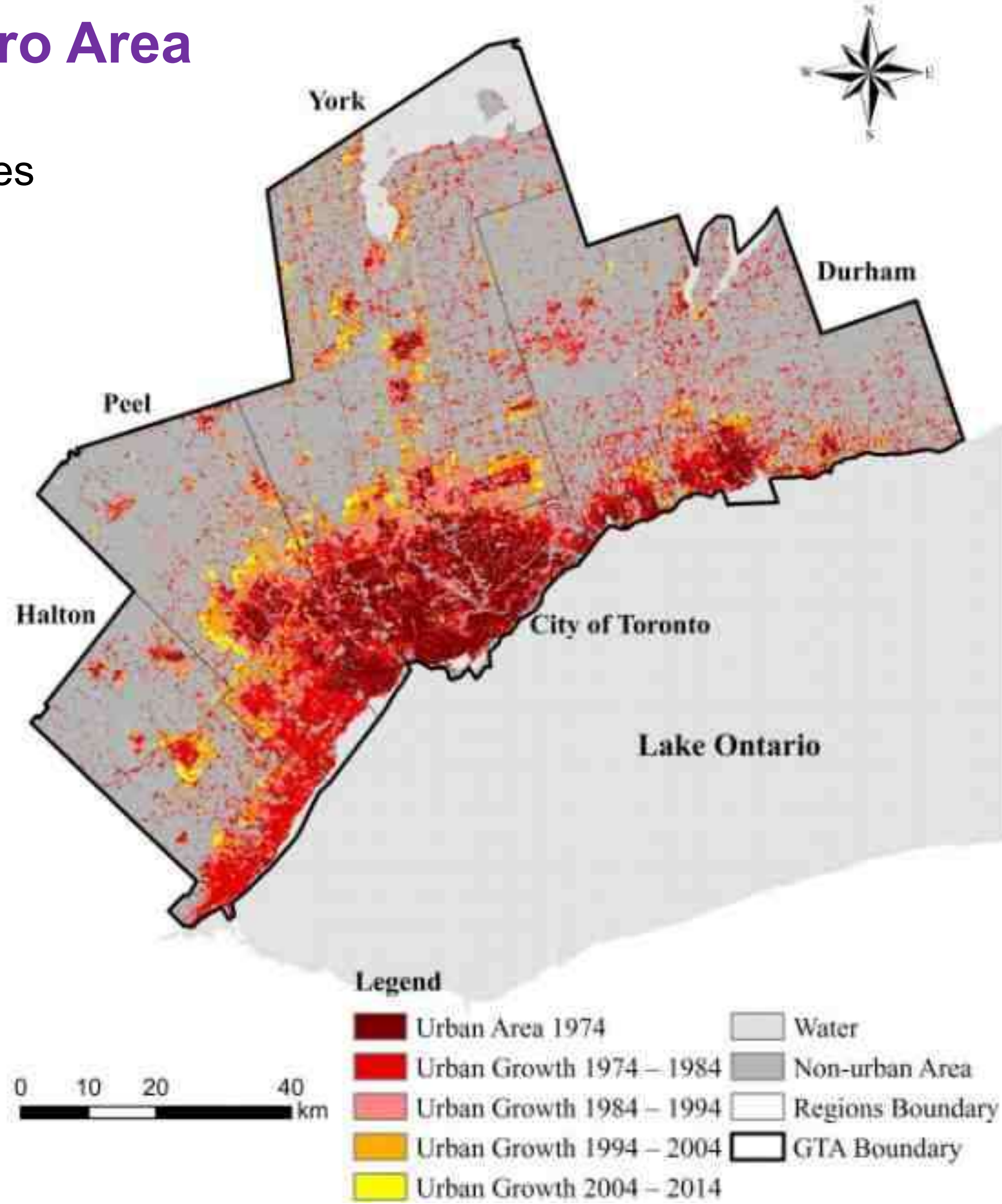
	1984		1999		2010	
LULC type	**km²**	**% of total**	**km²**	**% of total**	**km²**	**% of total**
Cropland (CL)	23.27	0.82	31.70	1.12	18.82	0.66
Coniferous forest (CF)	1059.06	37.35	1175.45	41.45	1107.84	39.05
Deciduous forest (DF)	796.65	28.09	660.79	23.30	815.34	28.83
Mixed forest (MF)	351.97	12.41	451.57	15.92	365.88	12.87
Planted or regrowth forest (P/RF)	59.94	2.11	140.08	4.94	157.23	5.53
Cut block (CB)	44.70	1.58	43.46	1.54	26.38	0.93
Pasture (PS)	6.53	0.23	51.63	1.82	60.30	2.12
Water (WT)	21.49	0.76	21.18	0.75	20.48	0.72
Wetland (WL)	454.22	16.02	220.82	7.79	183.30	6.45
Built-up area (BA)	18.17	0.64	39.32	1.39	47.24	1.66
Forest fire (FF)	0.00	0.00	0.00	0.00	33.19	1.17



Growth of Toronto Metro Area 1974-2014

Classification of 5 Landsat images





Someone could do the same for a PG final project ?