Next week – October 28 - Nov 1

Syllabus

28-Nov 1 Projects / Env. Change class demos *Lab 8: Change detection*

Tuesday: no lecture in class time – I will load the scheduled lecture on ‘Projects’ on the webpage by the weekend – also an announcement on Moodle
= project ideas / examples .. all relevant topics covered so far except DEMs (lab 9)

Wednesday: normal lab time on Change detection – hope Catalyst behaves ☺

Thursday (Halloween): class presentations on your Env Change slides (Lab 6)

Environmental change assignment (10%)
Summary of deliverables

powerpoint slides -> PDF (and yes images are not as full resolution as lab images)

1. Intro slide: general location, describe the event / change
 – could include a ground photo (or bing / google map)

2. Before image with date/year (fill slide with image as far as possible)

3. After image with date/year   (fill slide with image as far as possible)

Include a scale bar / location - name and lat/long (degrees/minutes- <u>not seconds</u>!)

x. Possible extra image as needed

Submit PDF via Moodle by Oct 30, 9pm

Present in class time (3 minutes each) on **<u>Oct 31</u>**

Change detection

.. Using repeat images from different time periods

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

2. Disolay: Digitise features /overlay

3. Digital analysis algorithms

a. Simultaneous display

b. Image algebra

c. Classification (multiple)

Image sequences for change

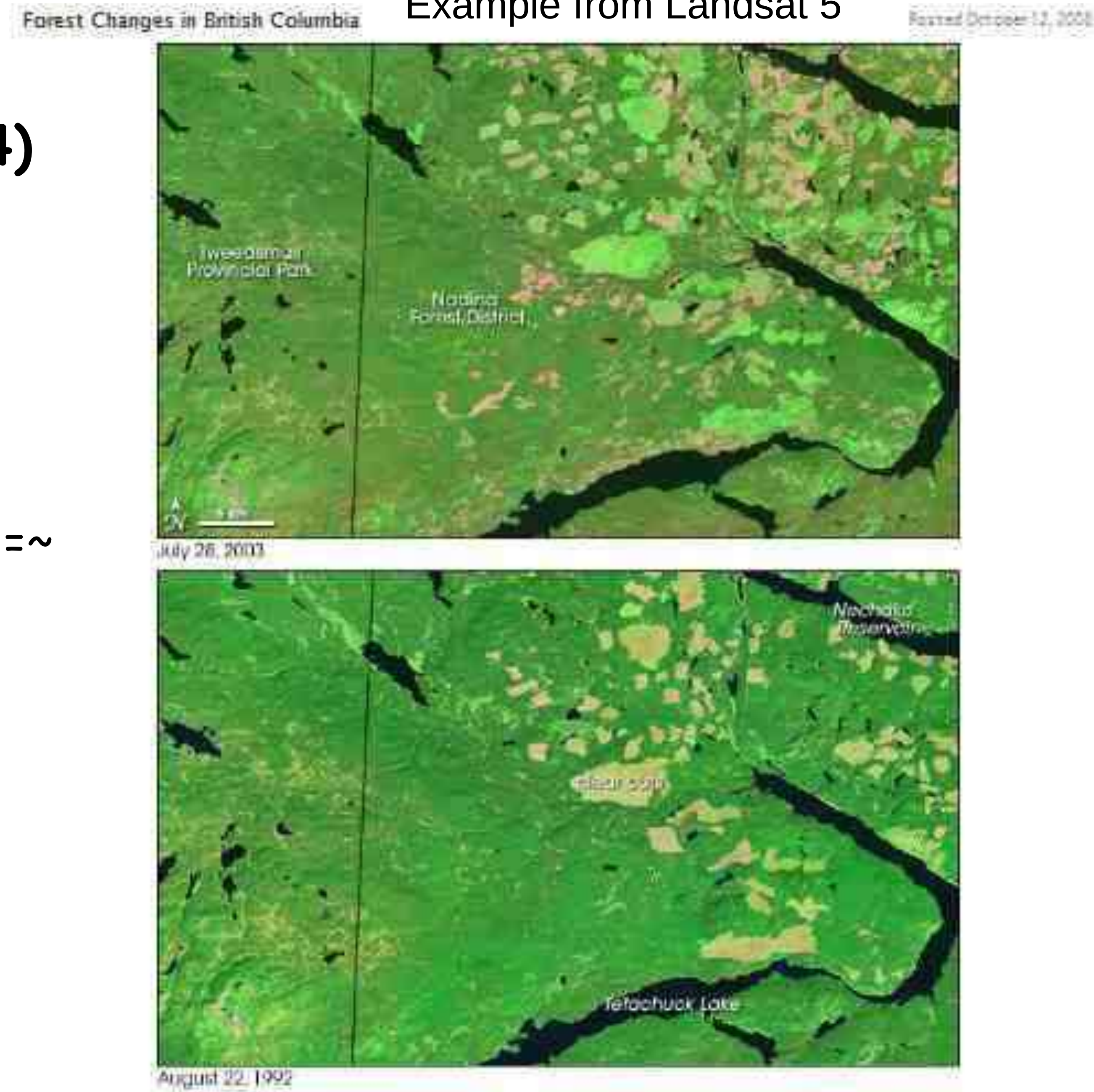
Ground photos/balloons	1850 ->
Air photos	1920 ->
Landsat MSS (80m)	1972 -> 1992 -> (2012)
Landsat TM (->ETM+ / OLI)	1984 -> 2002-> 2013->
AVHRR (1km) NDVI	1979 ->
High resolution (1 m)	2000 ->
ASTER / MODIS	2000->
Sentinel 2	2015 ->

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



Change monitoring Considerations 1

Timing (day/season)

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

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

- Seasonal ground cover – vegetation, snow, crops

- Image data should be collected 'near' Anniversary Dates

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

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 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

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 <u>Anniversary</u> Dates

*What happens to **<u>Digital Numbers</u>** if sun angle is lower ??   Answer: ?*

Spatial resolution: Pixel size: Good registration is critical

Radiometric Resolution: range of digital numbers – 8 bit v 16 bit

Spectral resolution: Same wavelengths range

e.g. Landsat TM IR bands are not the same as L8 OLI or SPOT IR bands

These impact visual comparisons of RGB composites, but are <u>critical</u> for digital analysis methods

1. Side by side / slider

Landslide Dams the Chilcotin River

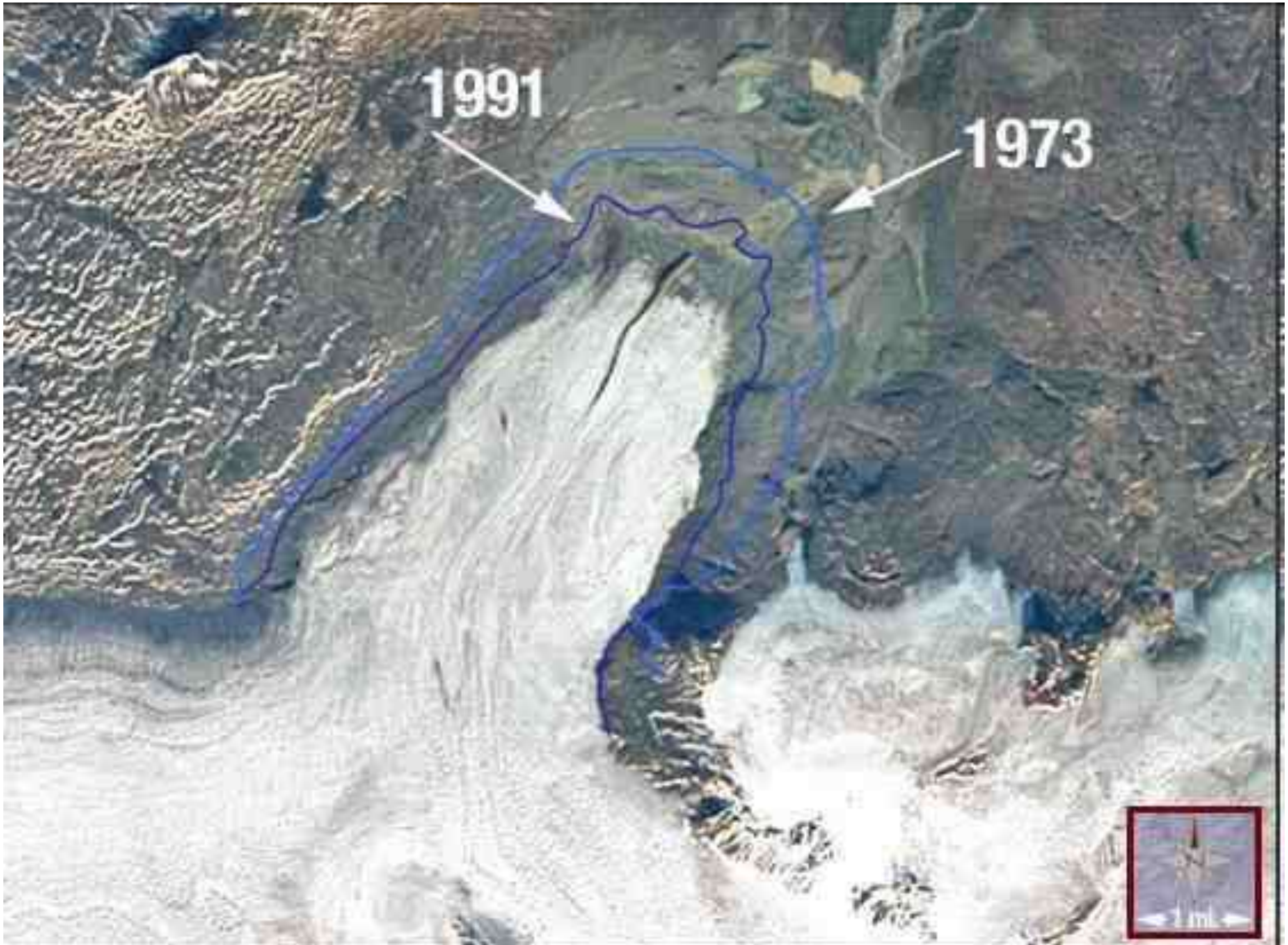
July 16, 2024 August 1, 2024

https://earthobservatory.nasa.gov/images/153158/landslide-dams-the-chilcotin-river

1. Side by side / slider

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

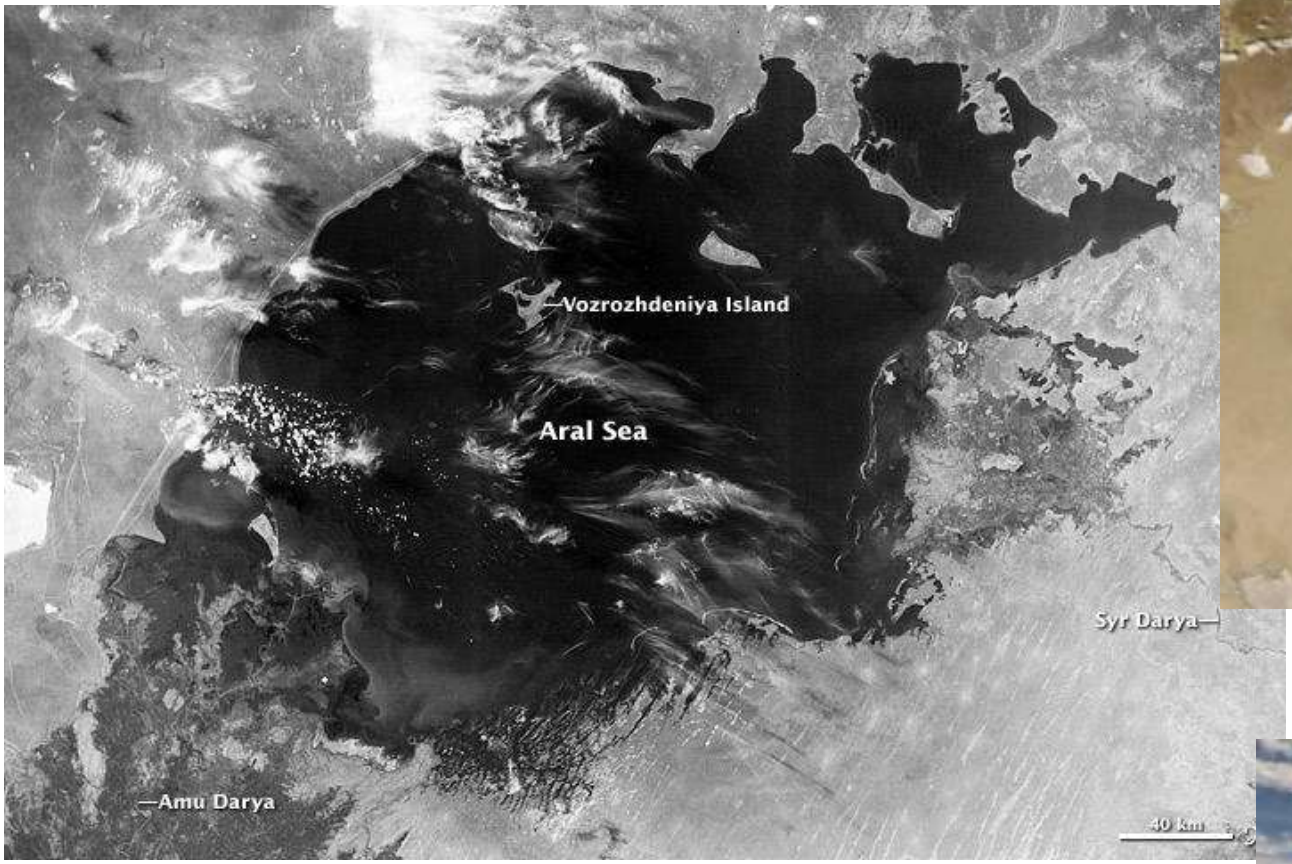
Digitised features: Eyjabakkajökull, Iceland

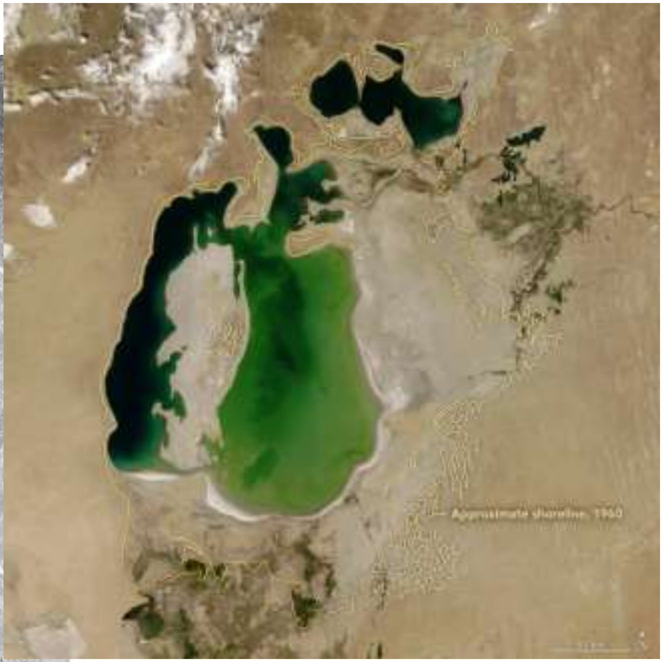


Generated from maps, digital vectors, or image processing – all initially remote sensing

Animation + Digitising: Aral Sea: Kazakhstan / Uzbekistan

http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php





Aral Sea 1964 from spy satellite

See also maps.google.ca - streetview

Digital algorithms

Digital analysis for change over time can operate on:

- **Individual bands**

- **Image channels** e.g. Ratios, NDVI, Tassel Cap

- **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)

1. simultaneous display - RGB

Prince George example
(band 3- Red):

2003 (B) July 22

2004 (G) Aug 9

2005 (R) Aug 19

Impact of reflection change

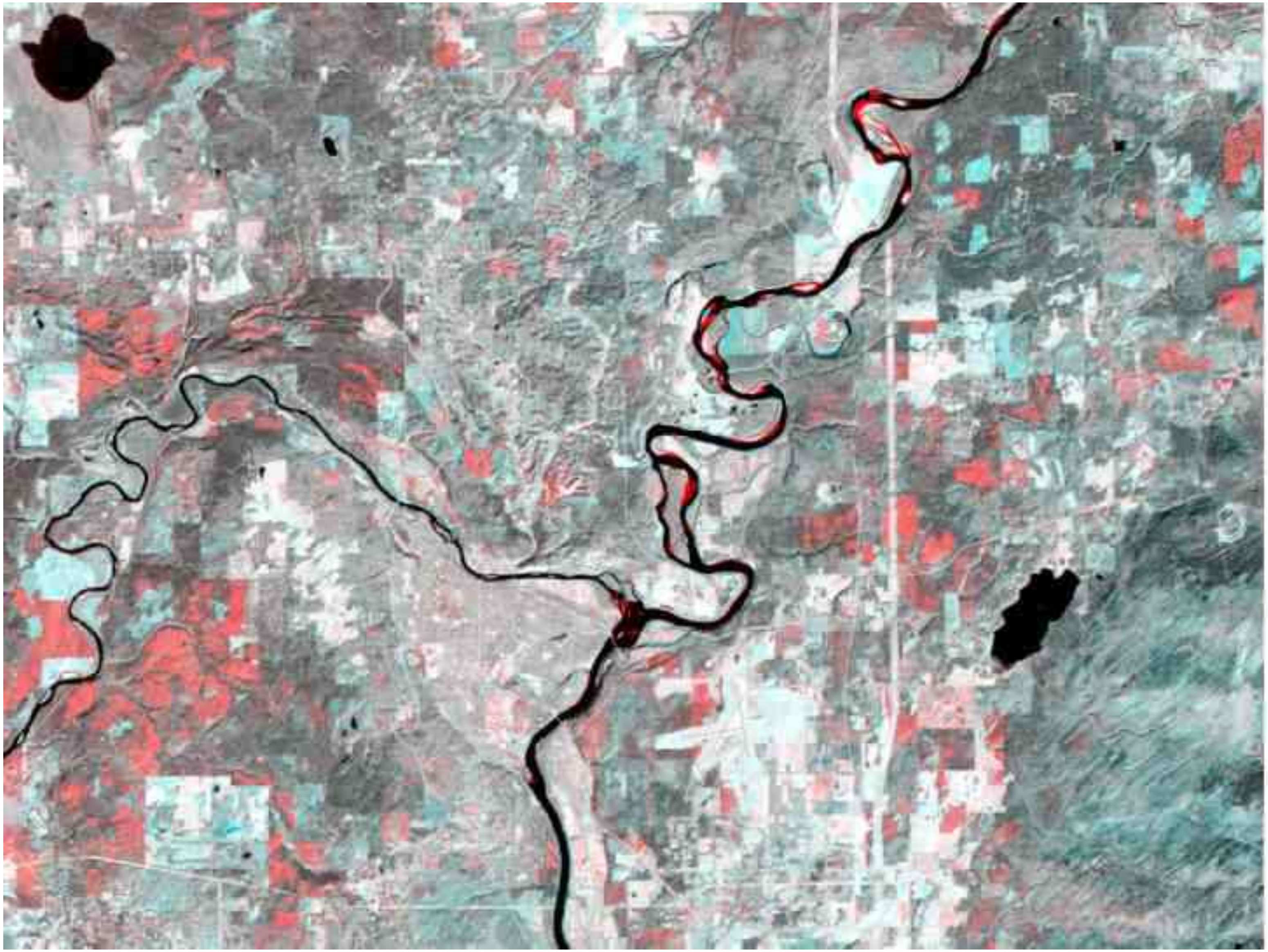
Increase = more red (Areas cleared)

Decrease = blue (regrowth)

No change = grayish

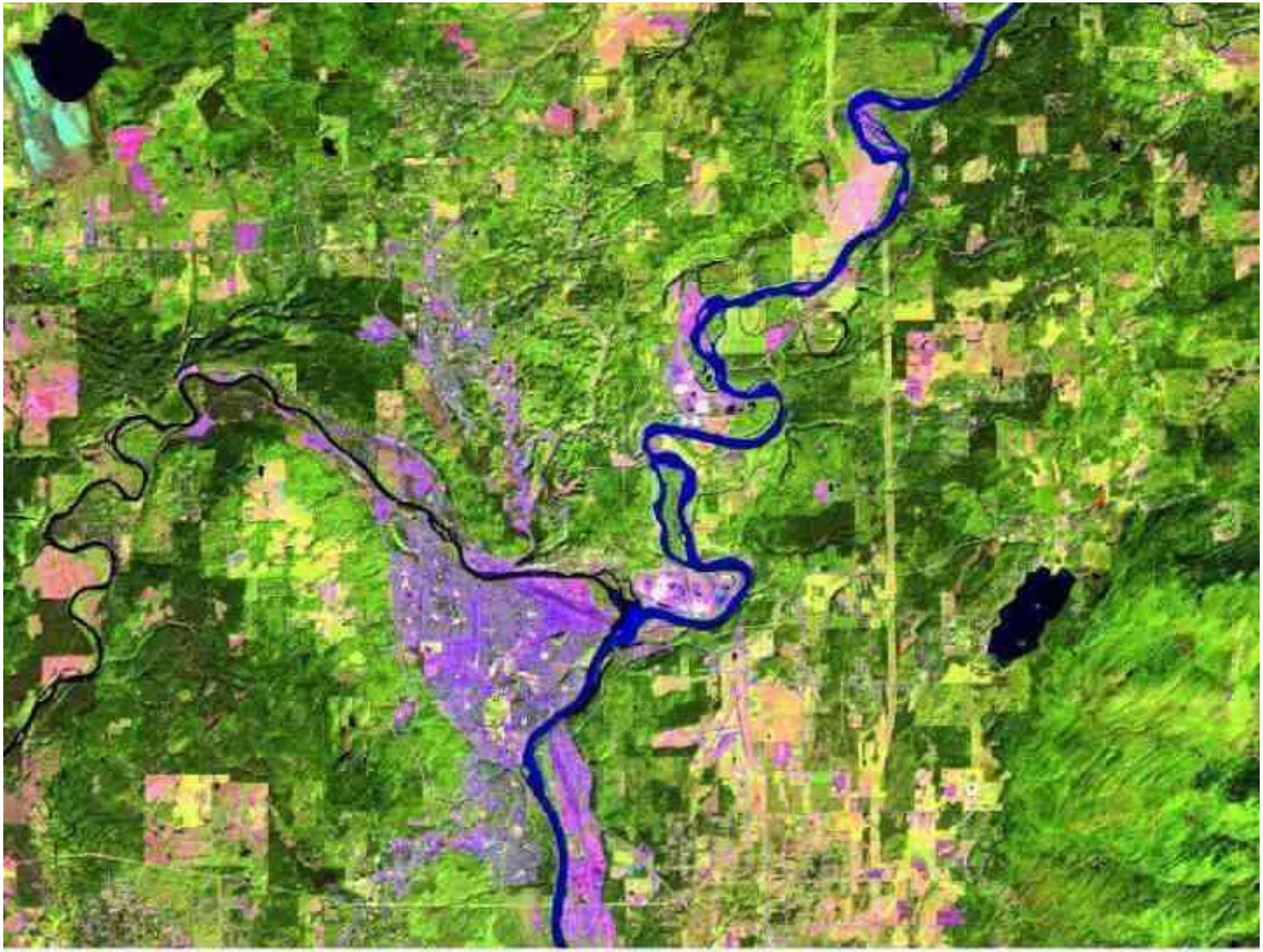
Seasonal: fields, river

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

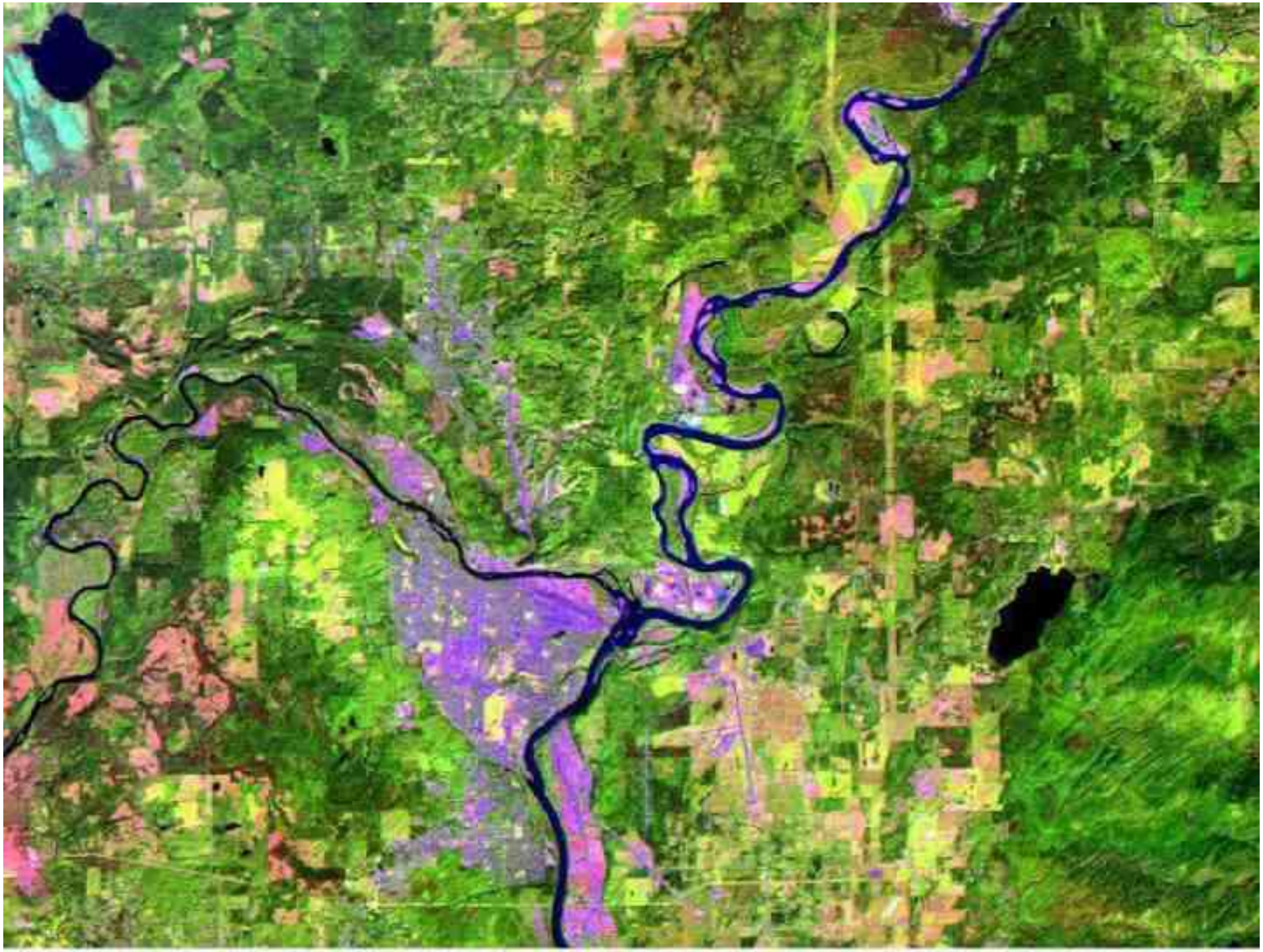


Band 5 (mid-IR), 2011 in red, 1996 in blue/green

1996



2011



Dubai has the world's largest artificial island, Palm Jumeirah, which is 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

August 24, 2001

Dubai – best to find similar dates by year -> **August 23, 2017**

Simultaneous display band 3 for 2000 (red) and 2006 (blue-green) - Dubai

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

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

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

= moisture decreases (soil and vegetation)

TIR: depends on time of day and season

see thermal lecture – hotter during the day

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 / signed channel)

Many reasons for variation (e.g. weather, haze 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 normalize

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

Impact of forest clearance on tasseled cap - would the DNs increase or decrease ?

- Brightness ?

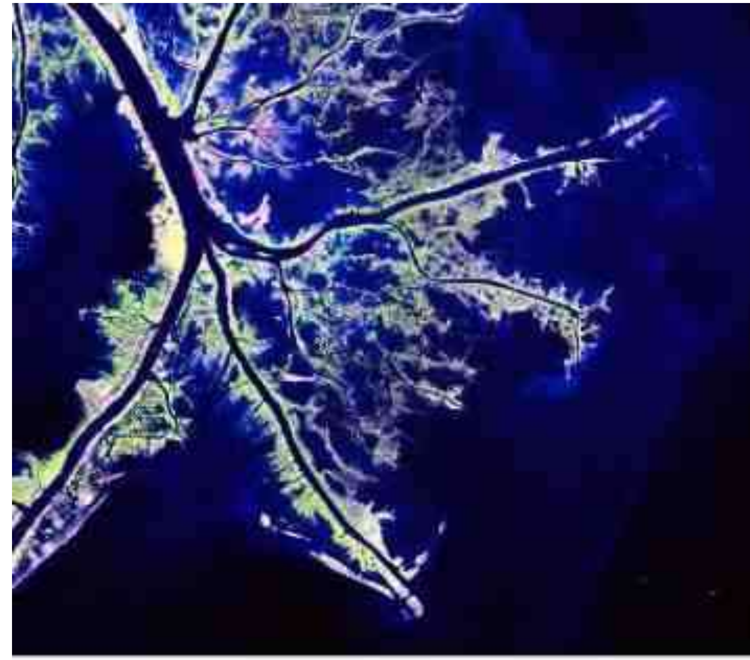
- Greenness ?

- Wetness ?

- NDVI (or 4/3 ratio) … similar to Greenness .. Why ?

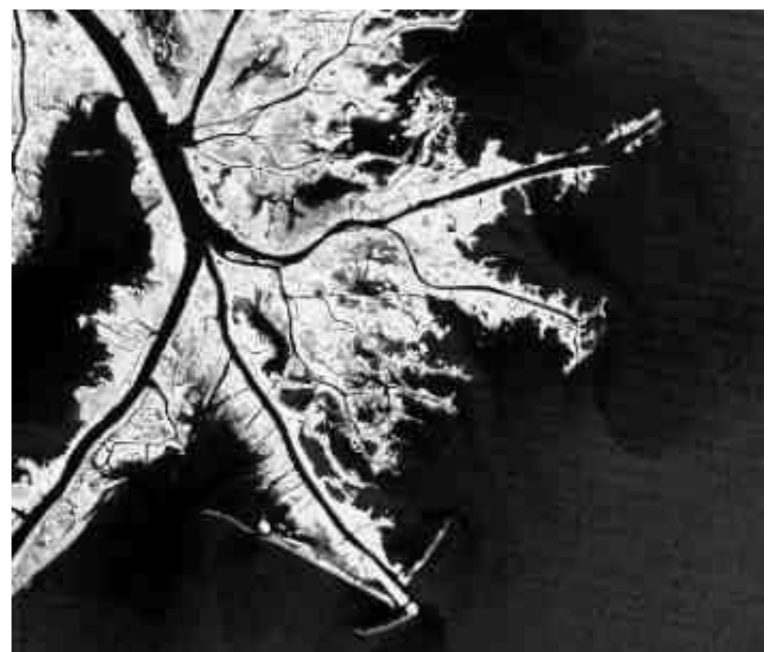
Mississippi Delta: TM543: 2004, 2005, 2010 (before/after Hurricane Katrina, Aug 2005)

2004



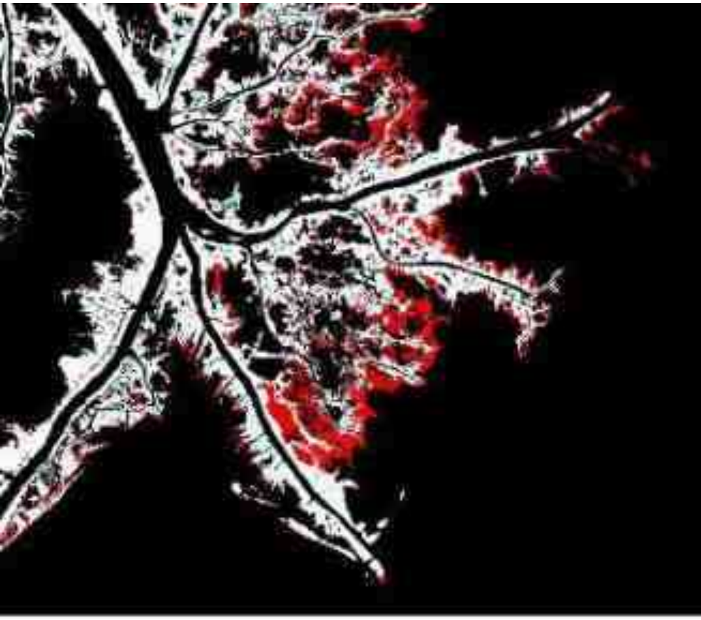
2005

2010

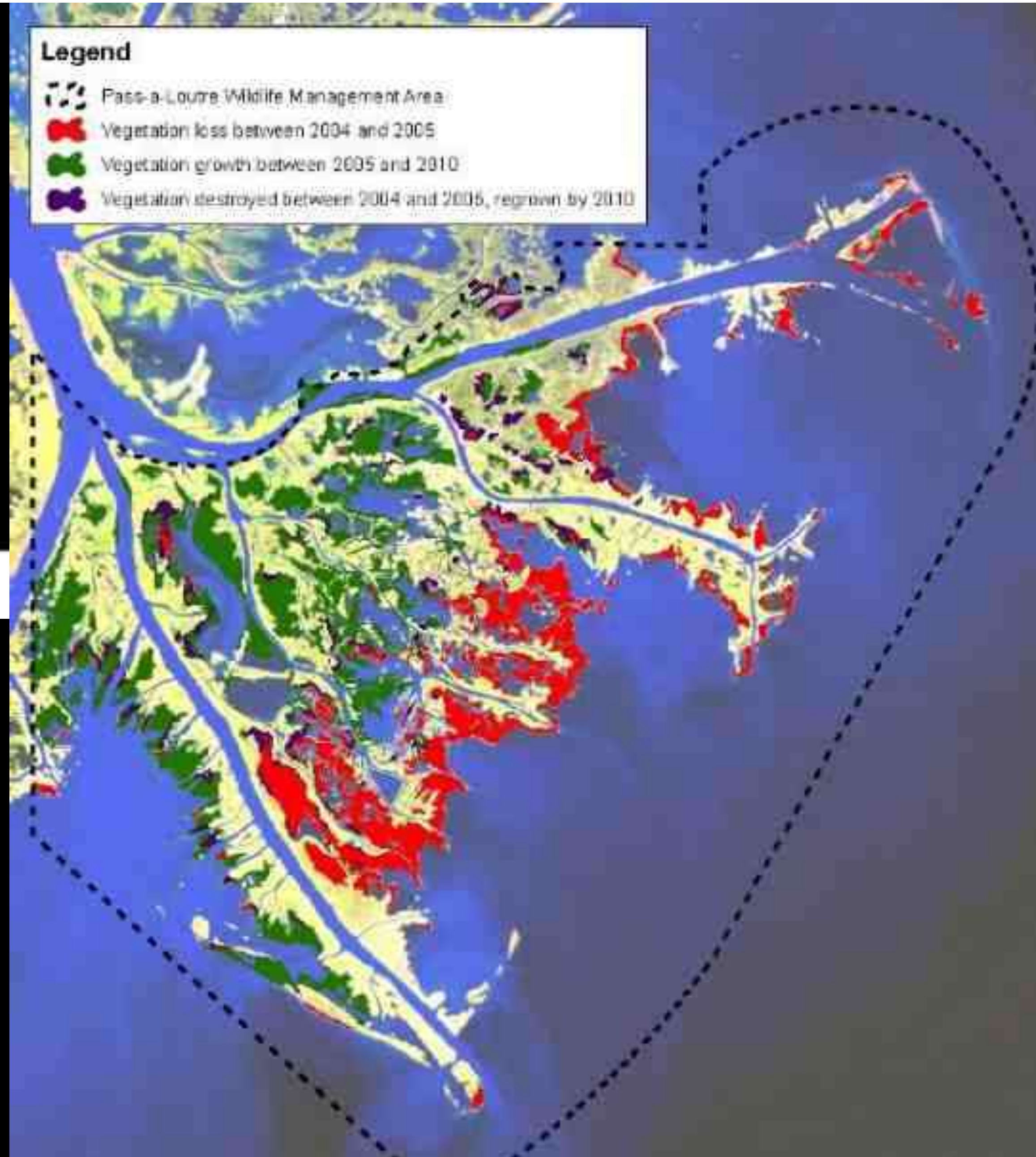


NDVI
2010

NDVI difference 2004-5

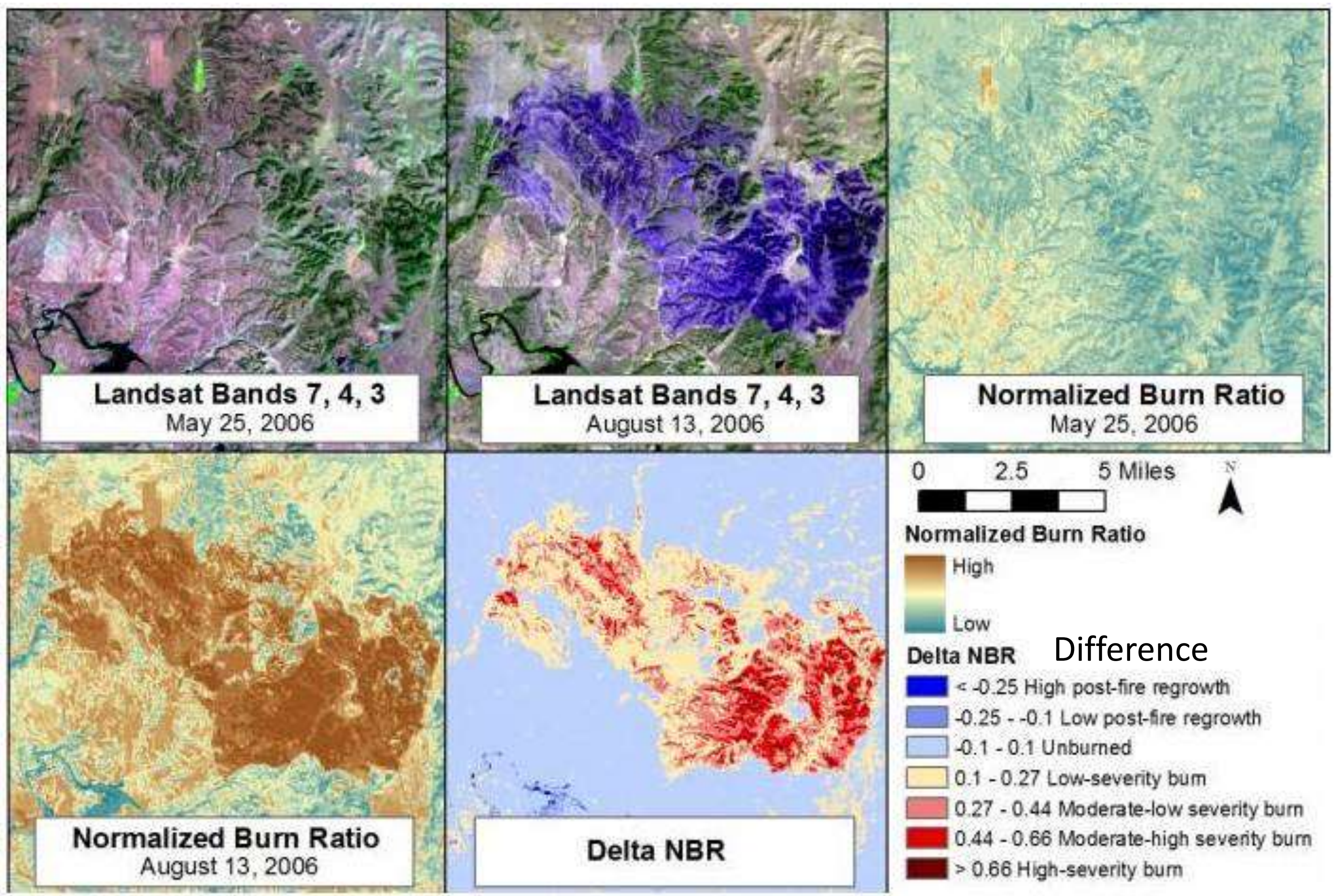


NDVI difference 2005-10

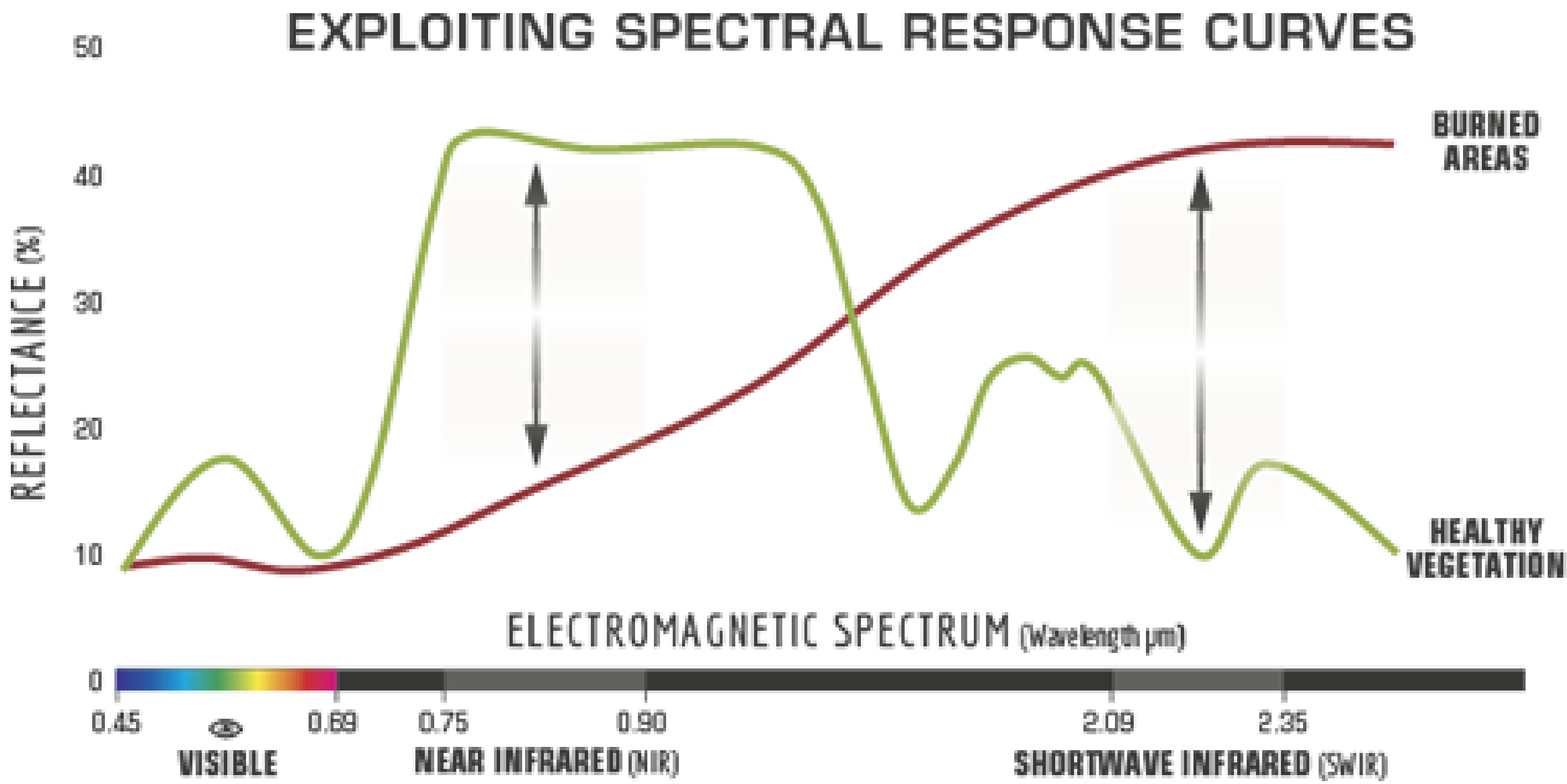


Normalised Burn Ratio (Index)

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



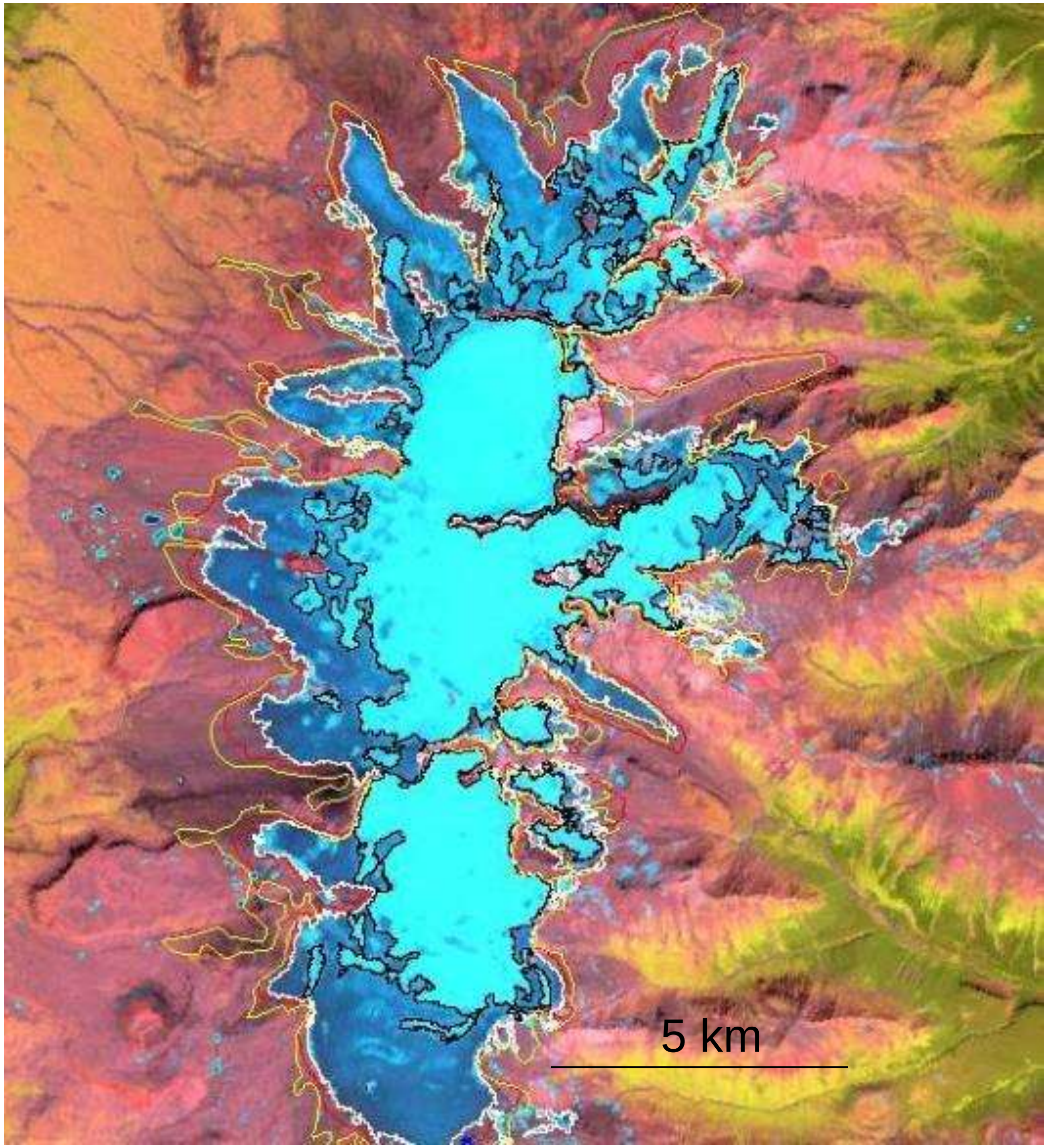
$$\mathrm{NBR} = \frac{NIR - SWIR}{NIR + SWIR}$$



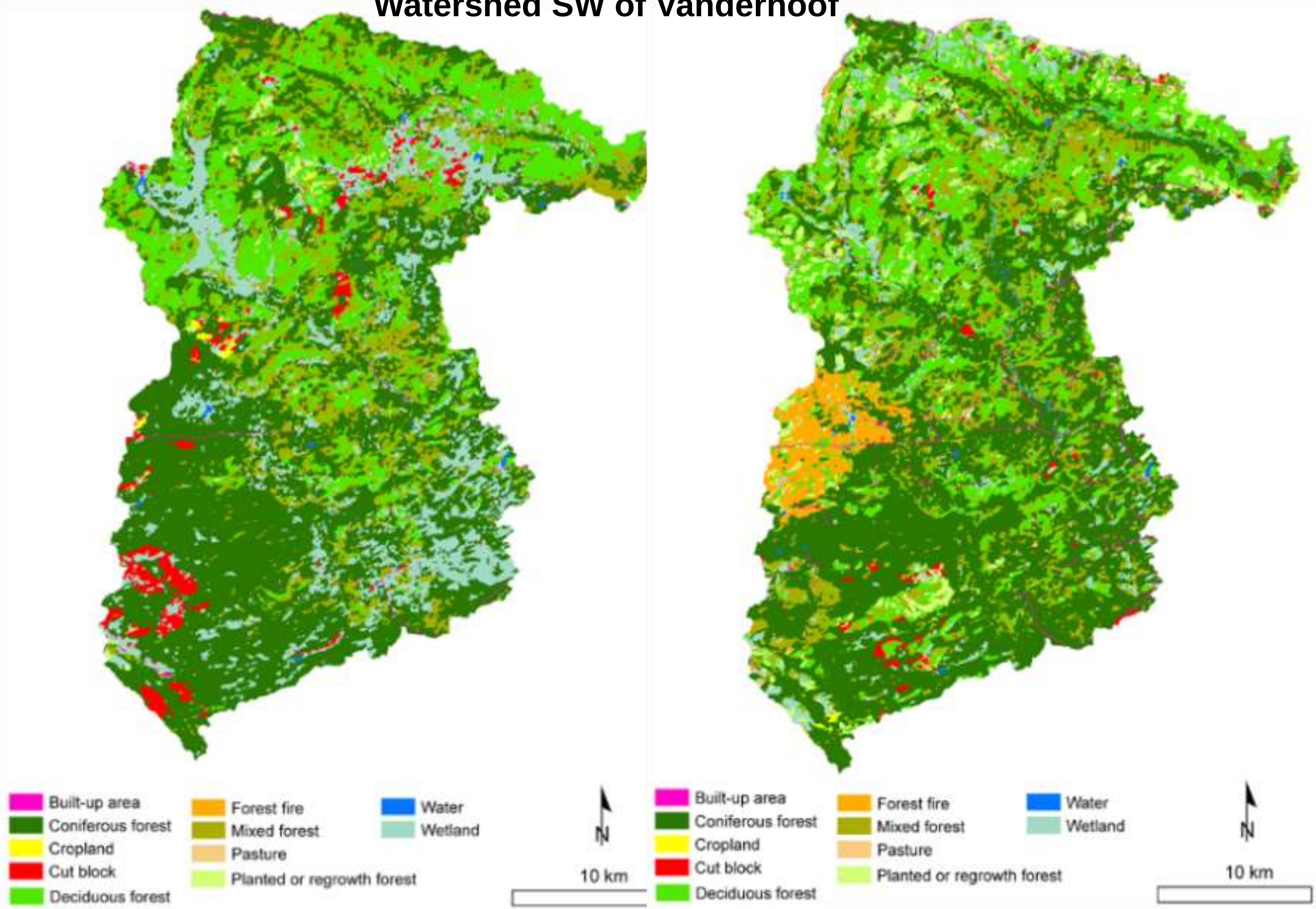
3. Classification: areas produced by supervised classification, 2000

Edziza: extents from NTDB 1966 (yellow), BC TRIM 1985 (red), Landsat 2000 (white / black)

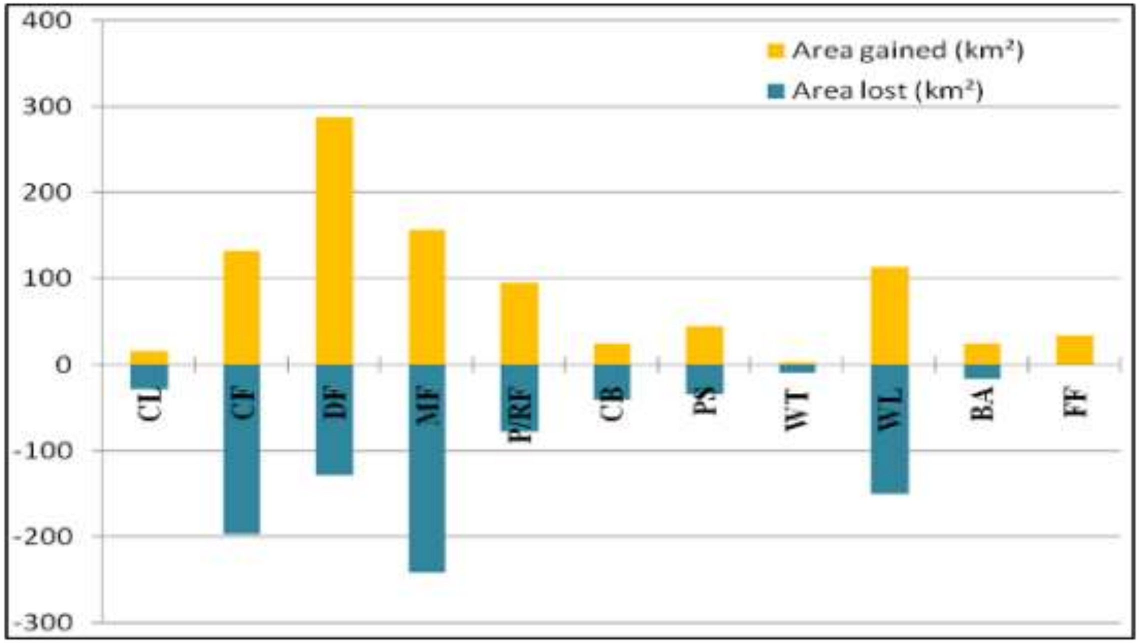
Training on ablation / accumulation areas



Recent 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



3. Post classification comparison: the 'matrix'

Two (usually supervised) classifications compared by pixel and cross tabulated: (example from J.Piwowar, U. Regina)

Time A (rows) / Time B (columns)

	Water	Cropland	Rangeland	Forest	Total
Water	2842	3	4	0	2849
Cropland	1	31874	596	0	32471
Rangeland	2	1063	72487	23	73575
Forest	0	8742	328	53221	62291
Total	2845	41682	73415	53244	171186

The matrix multiplies as number of classes increase

Could do a binary tabulation - change / no change - or selected classes only

Growth of Toronto Metro Area 1974-2014

Classification of 5 Landsat images