The UK seen from the international space station...

RS humour ....

Before and after aerial photographs - Brisbane Floods, Australia, January 2011

http://www.abc.net.au/news/specials/qld-floods/

Ground photos: http://explore.mountainlegacy.ca/

1993- PG map

Issues: time of day and year, shadows, media, registration

2003

UNBC 2006

Change detection

Using repeat images from different time periods

a. View side by side and/or with slider

b. In sequence (animation)

c. Digitise features /overlay

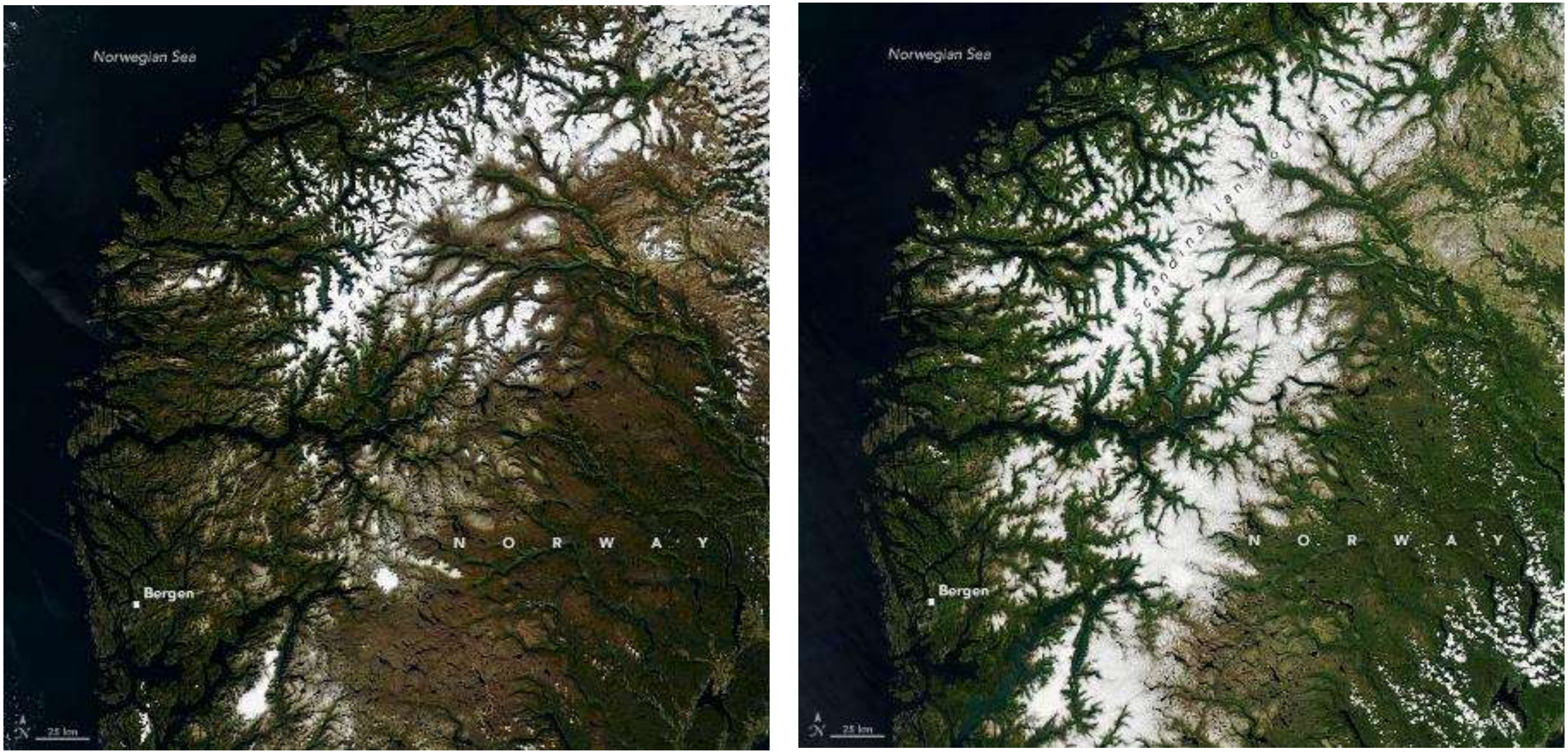
d. Digital analysis algorithms

Image sequences for change

Ground photos/balloons	1850 ->
Air photos	1920 ->
Landsat MSS (80m)	1972 -> 1992 -> (2012)
Landsat TM (->ETM+ / OLI)	1984 -> 2002-> 2022
AVHRR (1km) NDVI	1979 ->
High resolution (1 m)	2000 ->
ASTER (15m) /MODIS (1km)	2000->

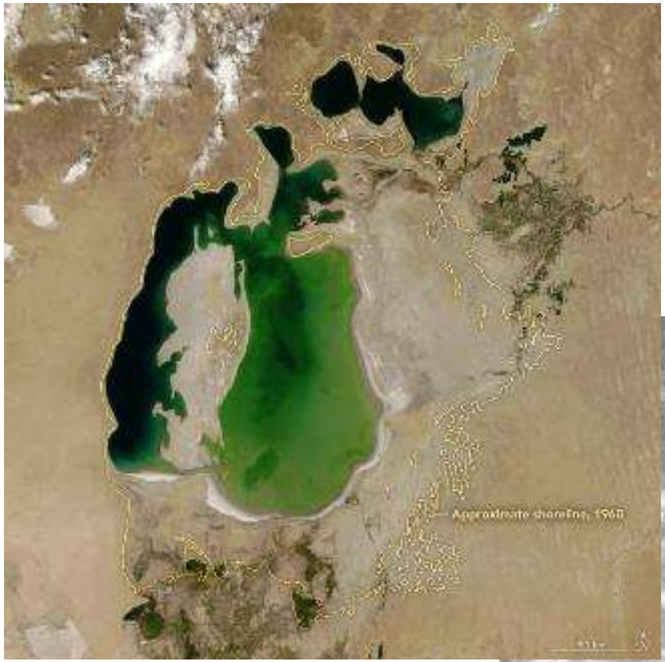
a. Side by side and overlay

https://earthobservatory.nasa.gov/images/150375/autumn-transformation-in-southern-norway



The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s Terra satellite acquired an image (left) on September 20, 2022. For comparison, the second image (right) shows the same area on June 29, 2022. In this early-summer view, acquired by MODIS on NASA’s Aqua satellite, snow was still melting away and vegetation was greening in summer.

b. Animation: Aral Sea: Kazakhstan / Uzbekistan



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

https://www.youtube.com/watch?v=58JIeUqtNxg

Aral Sea 1964 from Corona spy satellite

b. Other examples

Google Earth Engine

https://earthengine.google.com/timelapse

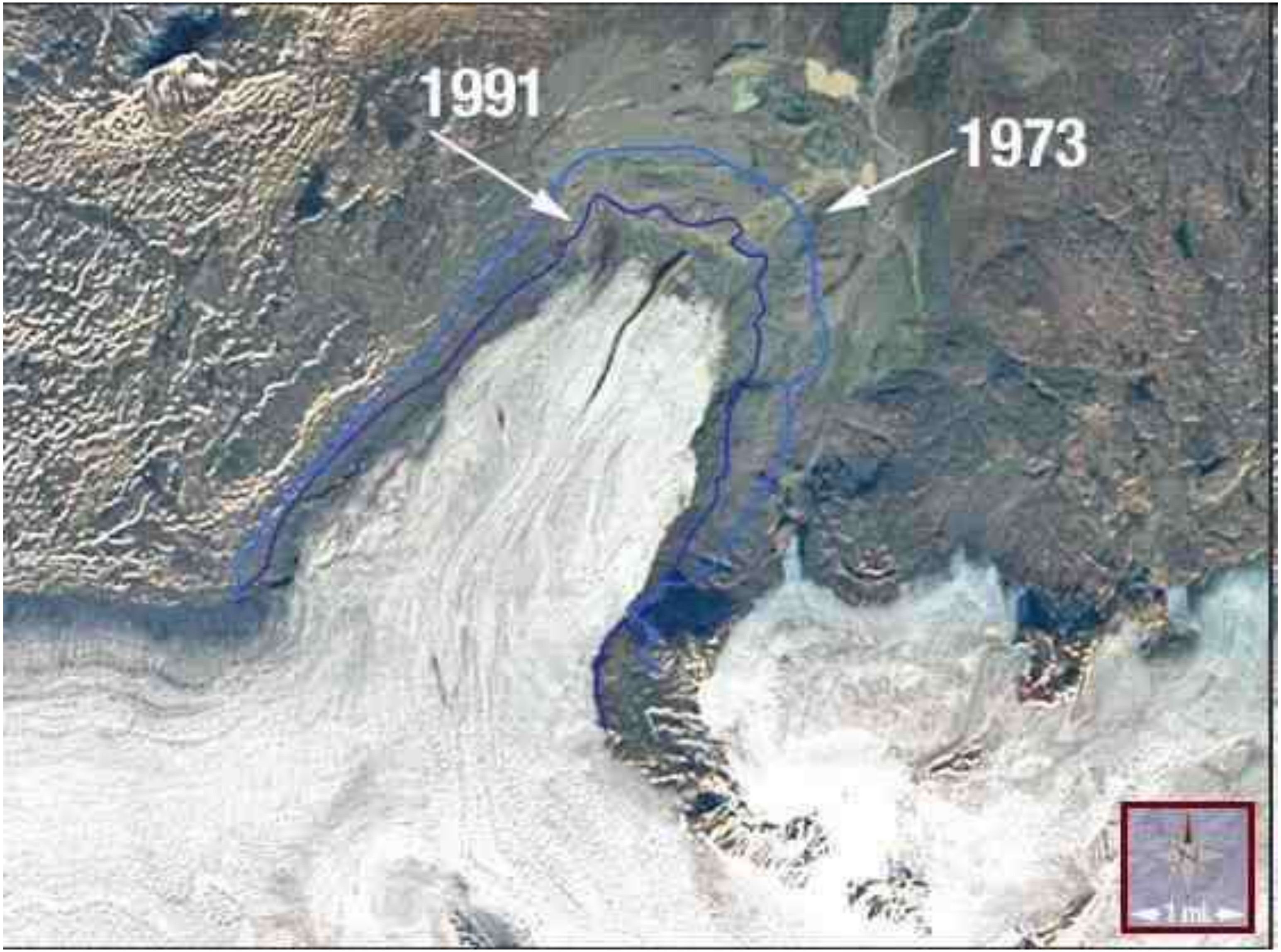
Google Earth examples

https://www.smithsonianmag.com/smart-news/google-earths-new-tools-shows-32-years-changing-planet-180961251/

Glacier Research

https://www.google.com/search?client=firefox-b-e&q=levan+tielidze+glacier+animation#imgrc=iv76DVB8CjkrtM

C. Digitised features: Eyjabakkajökull, Iceland



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

c. Glacier updating - western Canada (UNBC)

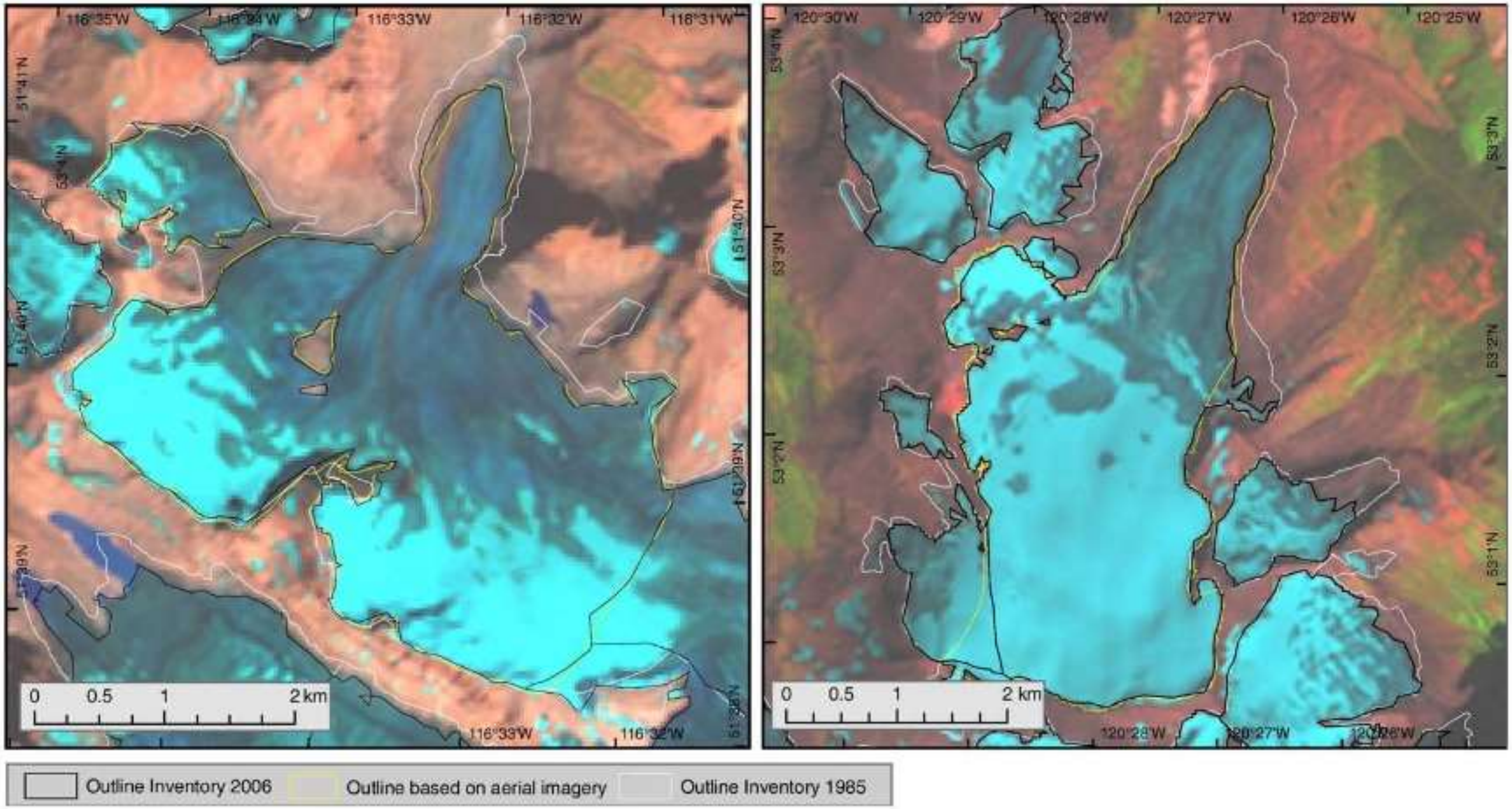


Fig. 4. Deviation of glacier outlines digitized manually from high resolution aerial photography (Matt Beedle, pers comm., 2007) and derived from Landsat TM data using our automated approach; left: Peyto Glacier in the southern Rocky Mountains, right: Castle Creek Glacier in the southern Interior Ranges; the arrows indicate problematic areas: A: Drainage basin delineation, B: Different interpretation of snow cover, C: Internal rocks, D: Debris-cover.

Change monitoring Considerations 3

[1. Time of day / season; 2. Types of changes]

Environmental

- **atmospheric conditions**
- **soil moisture conditions**
- **recent weather e.g. rain / snow**

… these all mean that a change in DN does not = ‘real’ change …

Change monitoring considerations 4: resolutions

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

Spatial resolution: Pixel size: Good registration is critical

Radiometric Resolution: range of digital numbers e.g. 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 may be factors in visual comparisons of RGB composites, but are <u>critical</u> for digital analysis methods

Digital algorithms

Digital analysis for change over time can operate on:

- **Individual bands**
- **Image channels** e.g. Ratios, NDVI, Tassel Cap, PCA
- **Classified images**

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

3-date colour composite

Prince George

(band 3):

2003 (B) July 22

2004 (G) Aug 9

2005 (R) Aug 19

Impact of reflection change

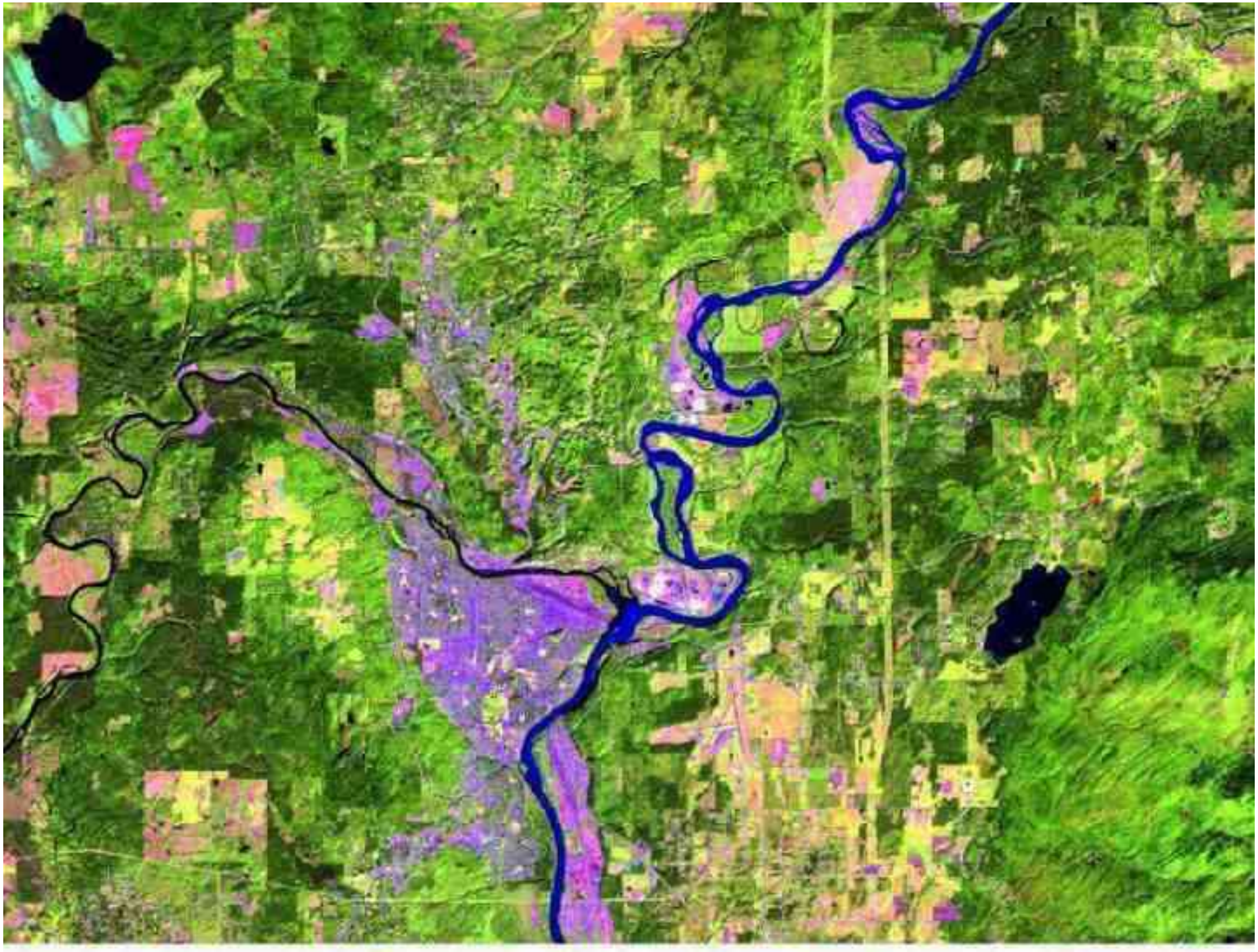
Increase = more red
(Areas cleared)

Decrease = blue/green
(regrowth)

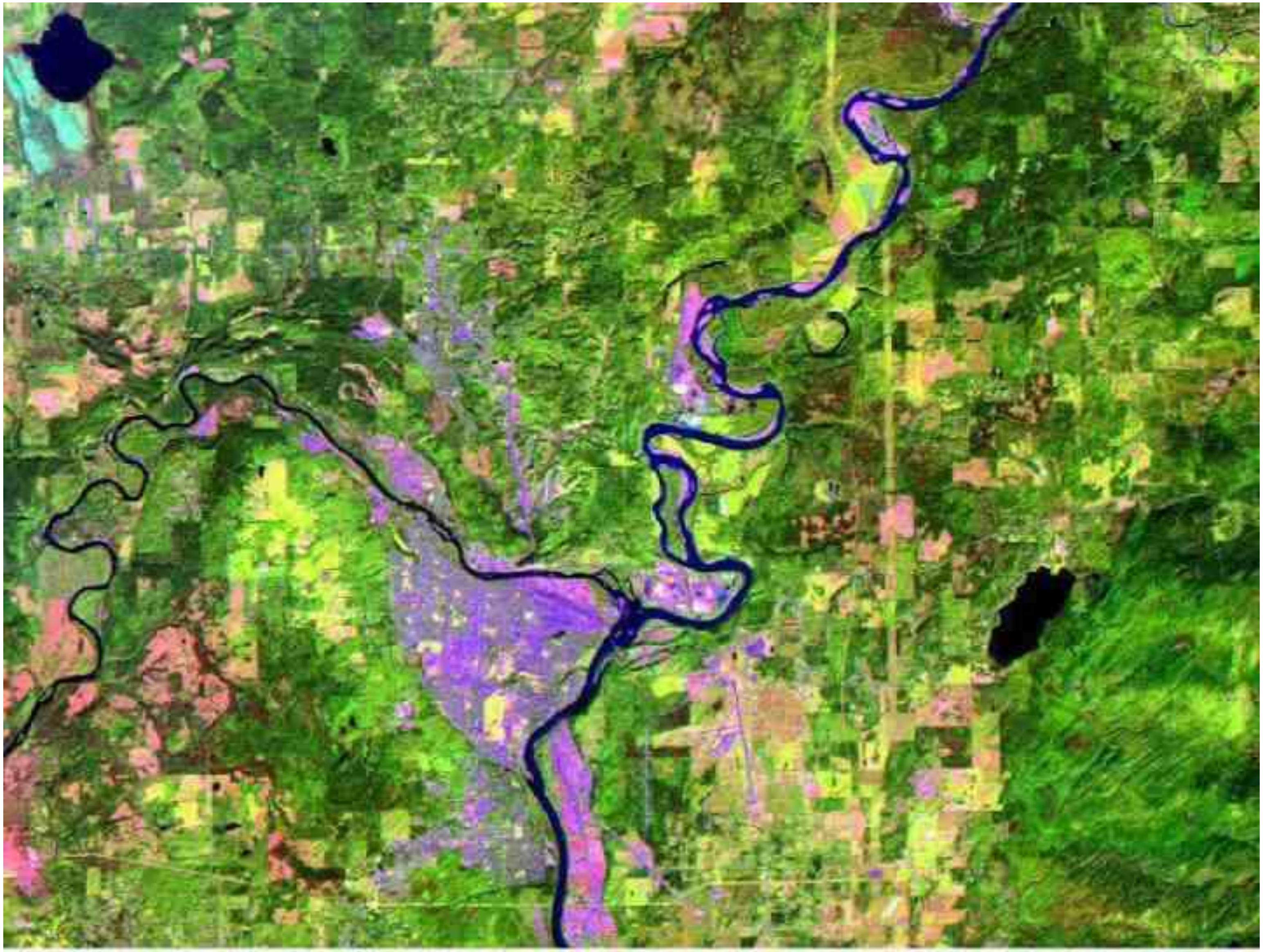
No change = grayish

Seasonal: fields, river

2 date example



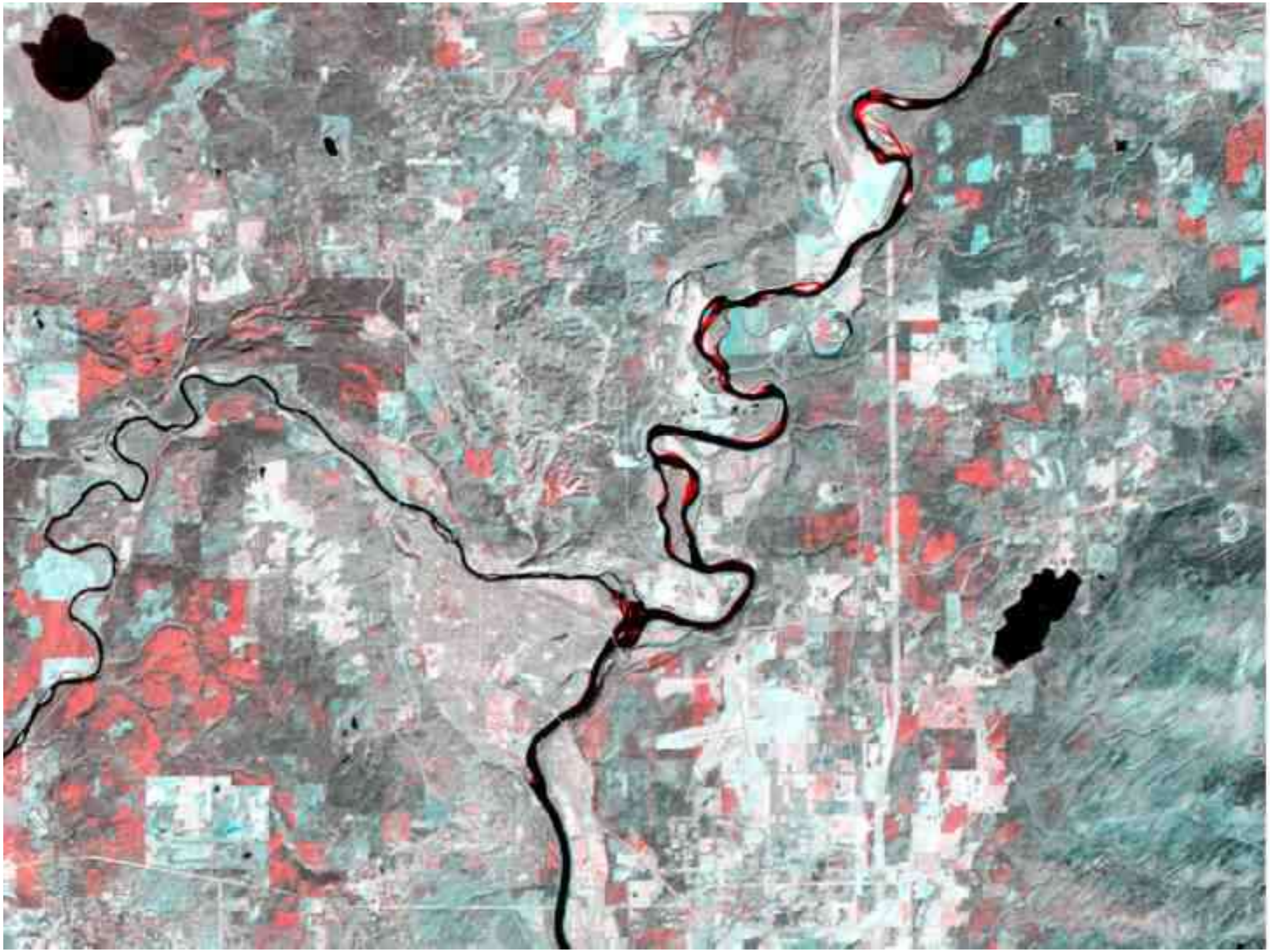
1996



2011

Some issues: clouds, cropland / seasonal flux

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

Dubai

August 24, 2001

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

Simultaneous display bands 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

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)

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

Output to 8 bit (+ or -), or 16 bit **signed** channel ?

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

Mean and standard deviations for DNs in Bowron subscene 1998 and 2009

- These numbers below indicate ability to compare as they are fairly similar means/sd especially IR bands

	1998		2009	
Band	Mean DN	sd	Mean DN	sd
1	52	18	59	27
2	23	11	26	18
3	19	14	23	22
4	53	23	56	25
5	46	26	46	24
6	128	8	133	8
7	18	13	19	12

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 then 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

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

Image algebra – differencing

- Subtract Band (same band) date A – date B

  …. or also ratio date A/B

- But which band(s) to choose ?

- and what about other changes (e.g. haze adds to DN) – need to normalize (mean / std.dev)

- 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 ?

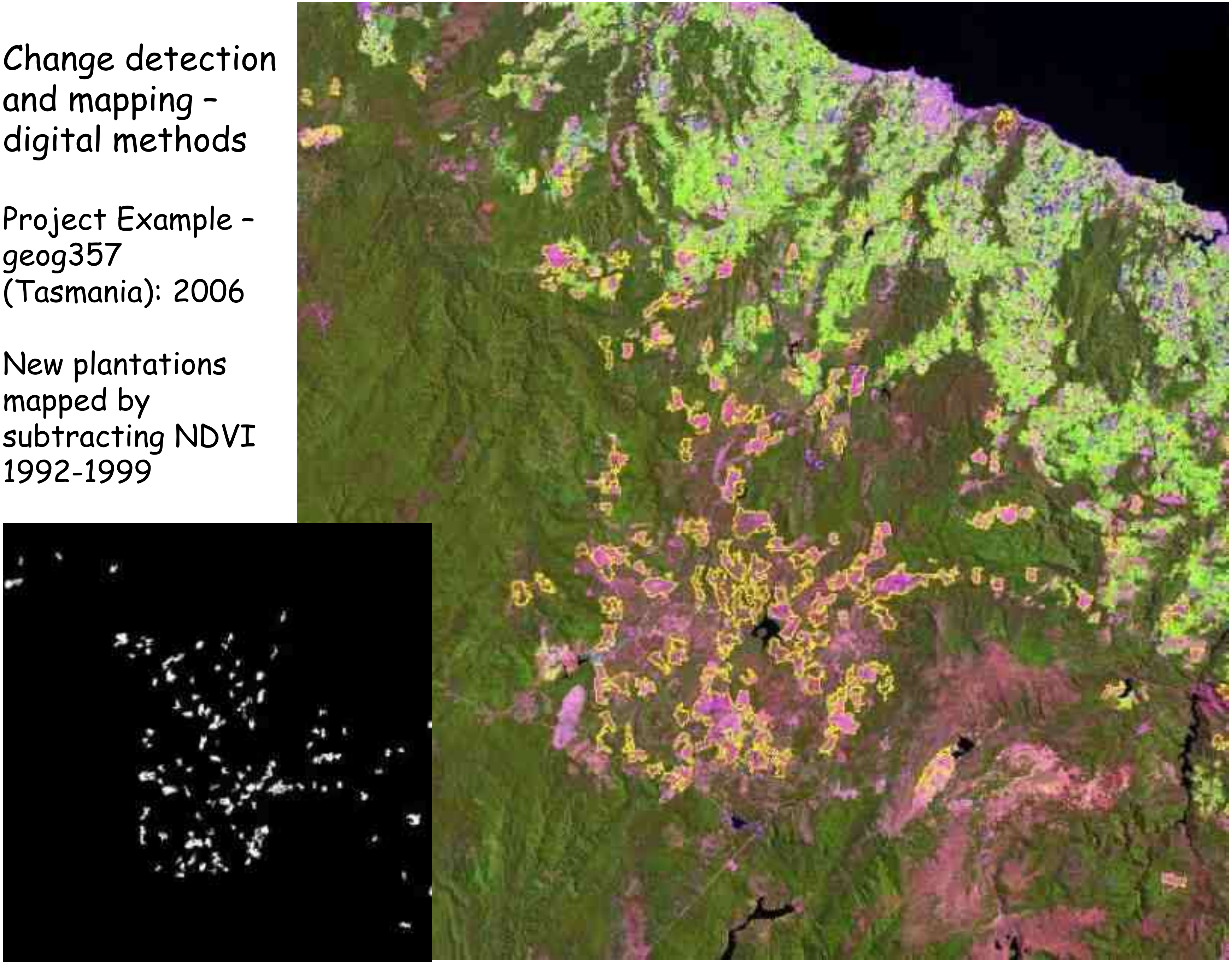
- Wetness ?

- NDVI (or 4/3 ratio)

Change detection and mapping – digital methods

Project Example – geog357 (Tasmania): 2006

New plantations mapped by subtracting NDVI 1992-1999



UNBC Geog357 project:

1992-1997 forest clearance

1992

Fig.1. Colour composite using bands 3,4 and 5 from

Fig. 2.Colour composite using bands 3,4 and 5 from 1997

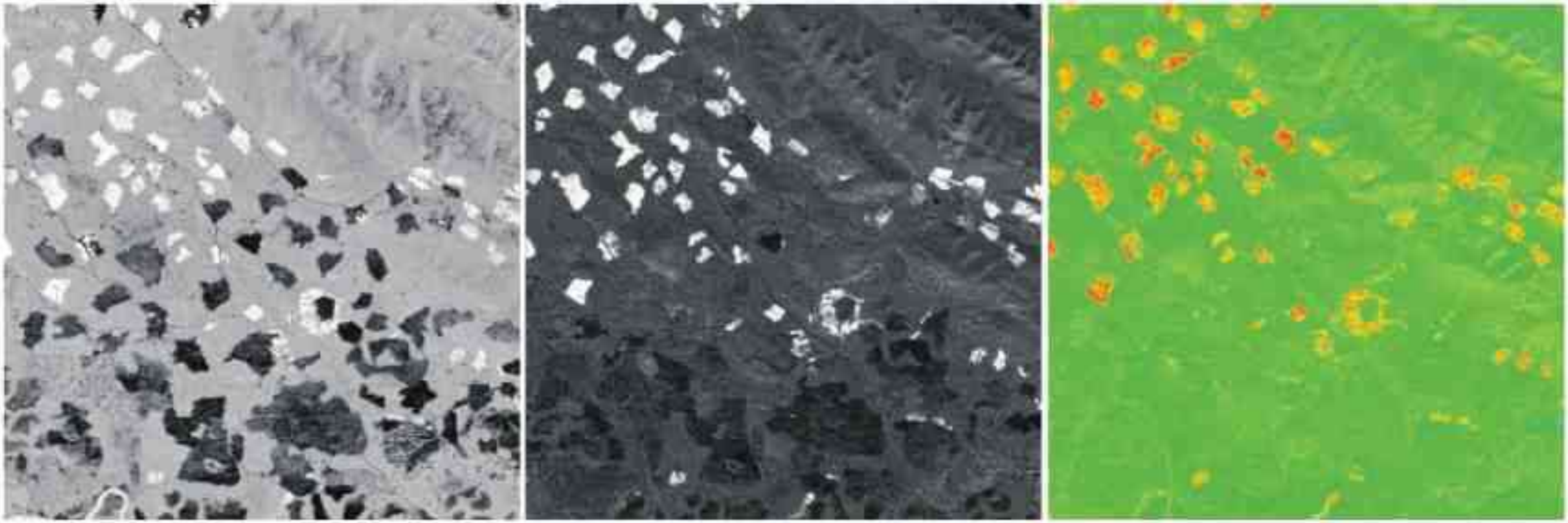


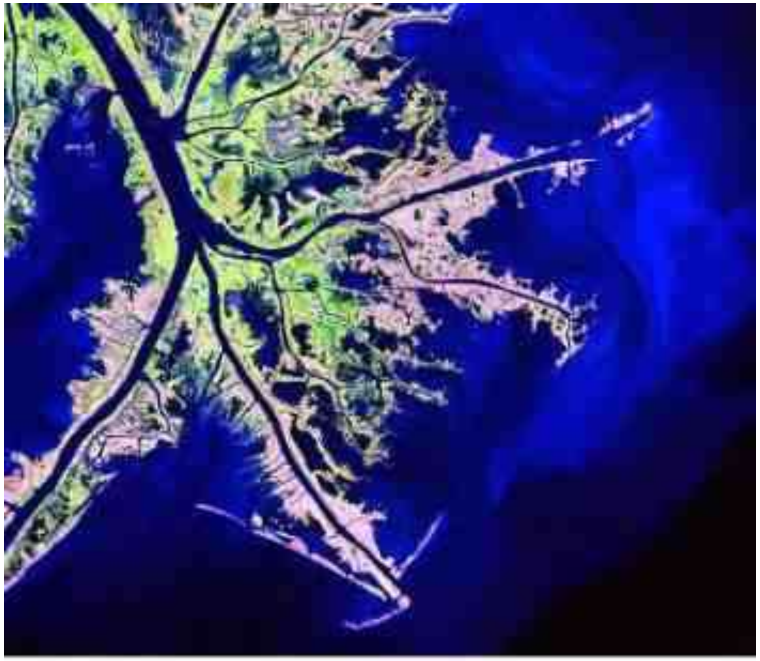
Fig. 3, 4 and 5. Tasseled Cap Wetness subtraction, PC2 and a pseudocolour display of the NDWI image subtraction respectively. Deforested areas are white in figures 3 and 4 and red in figure 5. Black areas were harvested prior to 1992.

1992-97 cutblock size has decreased

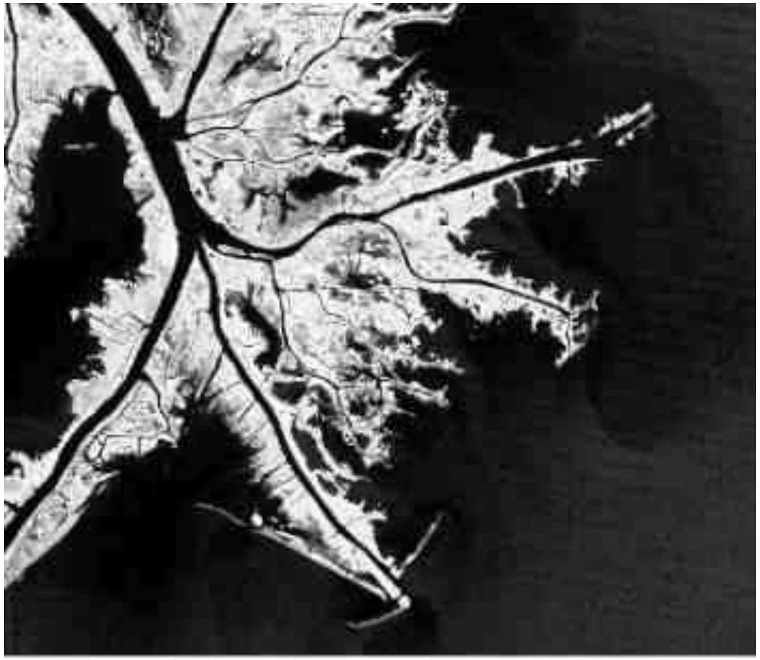
Mississippi Delta: TM543: 2004, 2005, 2010 (before/after Hurricane Katrina, Aug 2005)

2004

2005

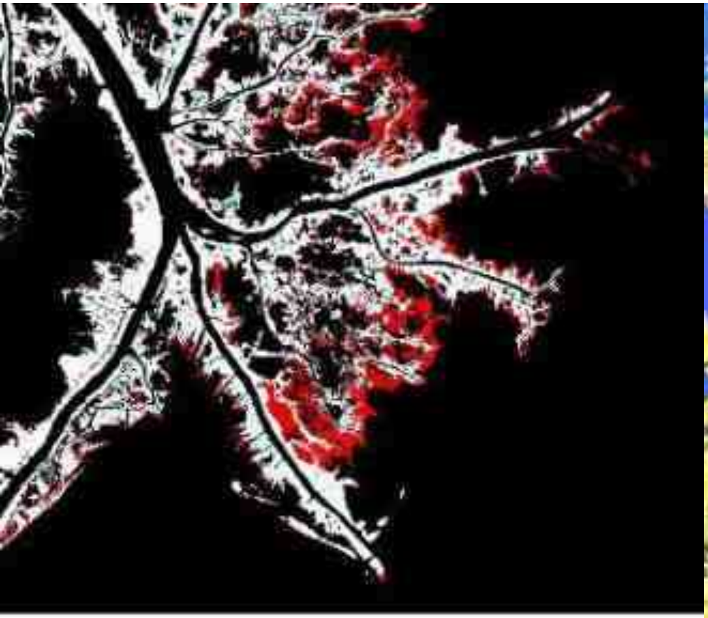


2010

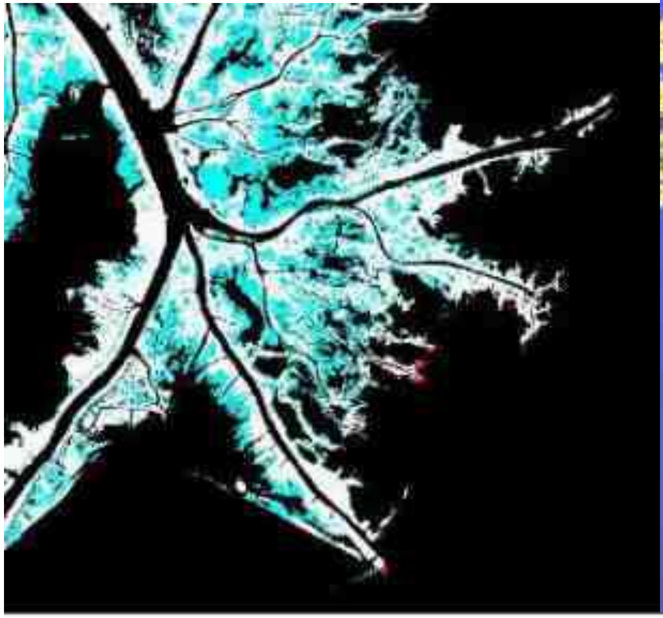


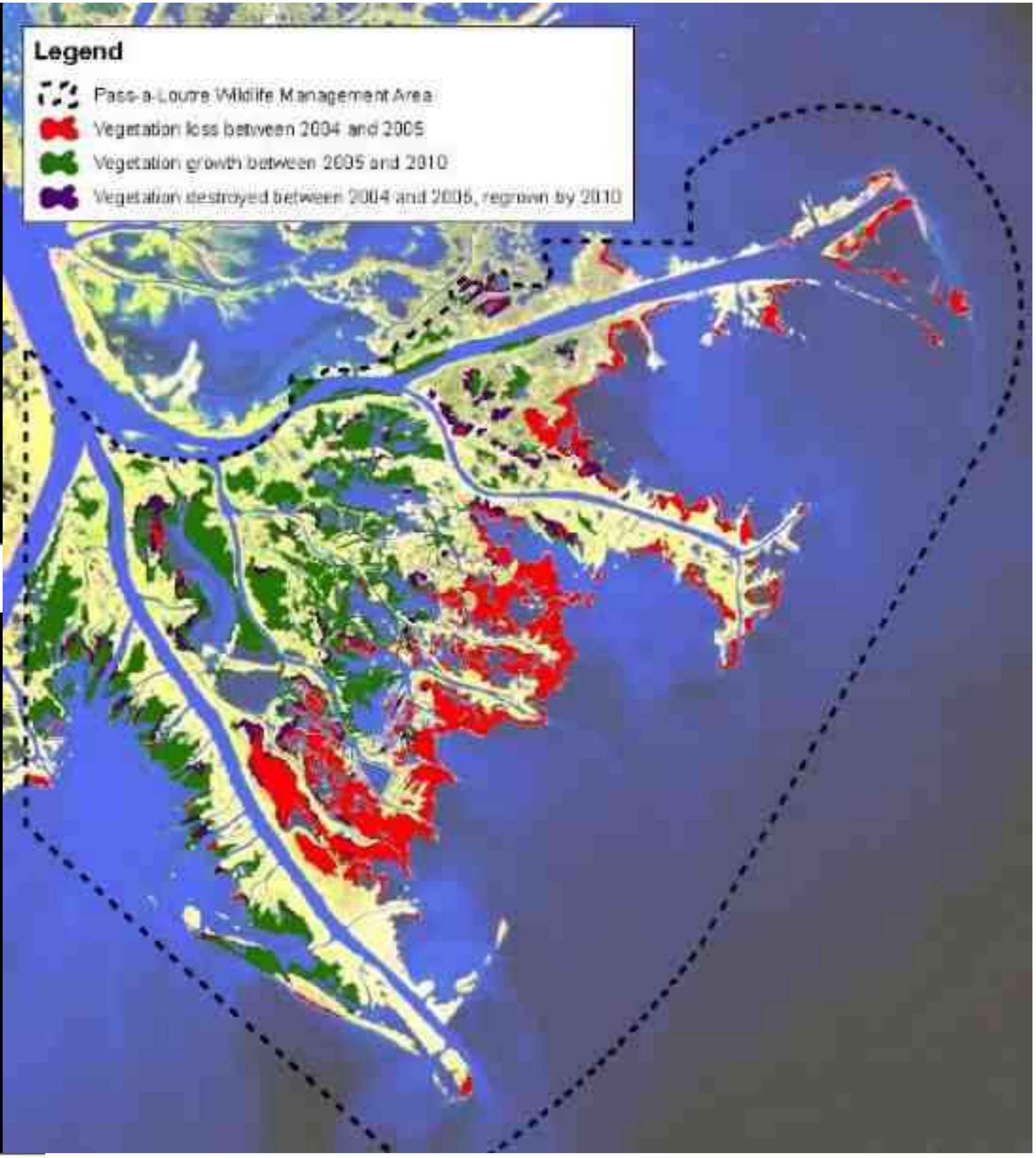
NDVI
2010

NDVI difference 2004-5



NDVI difference 2005-10

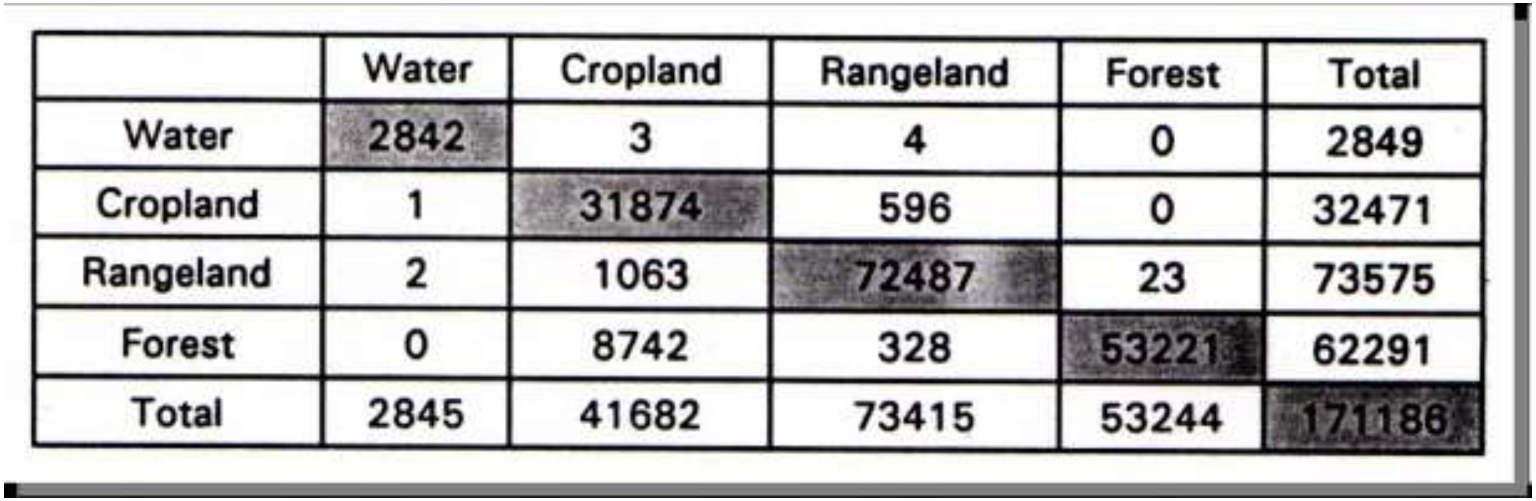




3. Post classification comparison: the 'matrix' (tool: MAT)

Two (usually supervised) classifications for 2 dates compared by pixel and cross tabulated: (example from J.Piwowar, U. Regina)

Time A



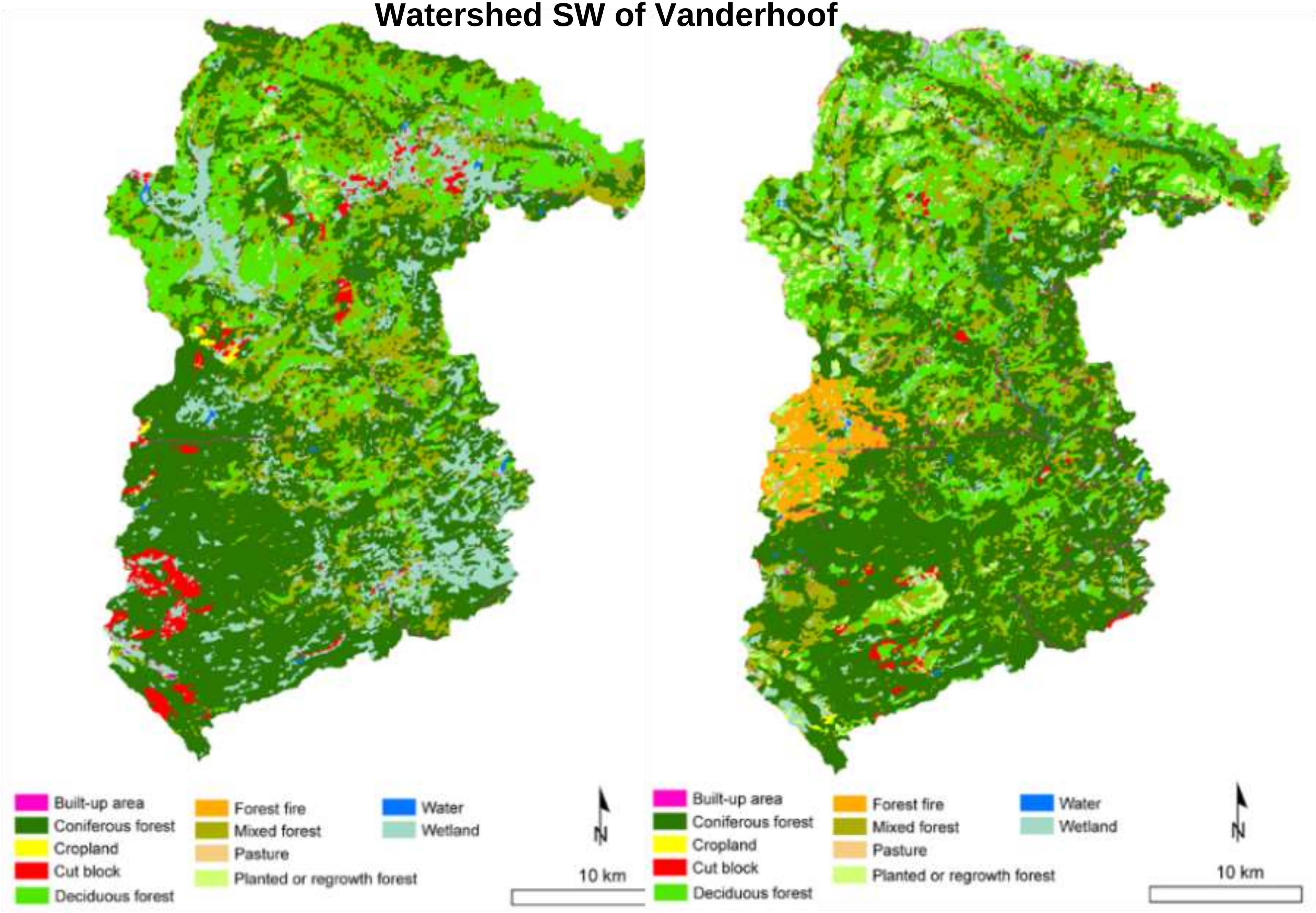
	Water	Cropland	Rangeland	Forest	Total
Water	2842	3	4	0	2849
Cropland	1	31874	596	0	32471
Rangeland	2	1063	72487	23	73575
Forest	0	8742	328	53221	62291
Total	2845	41682	73415	53244	171186

Time B

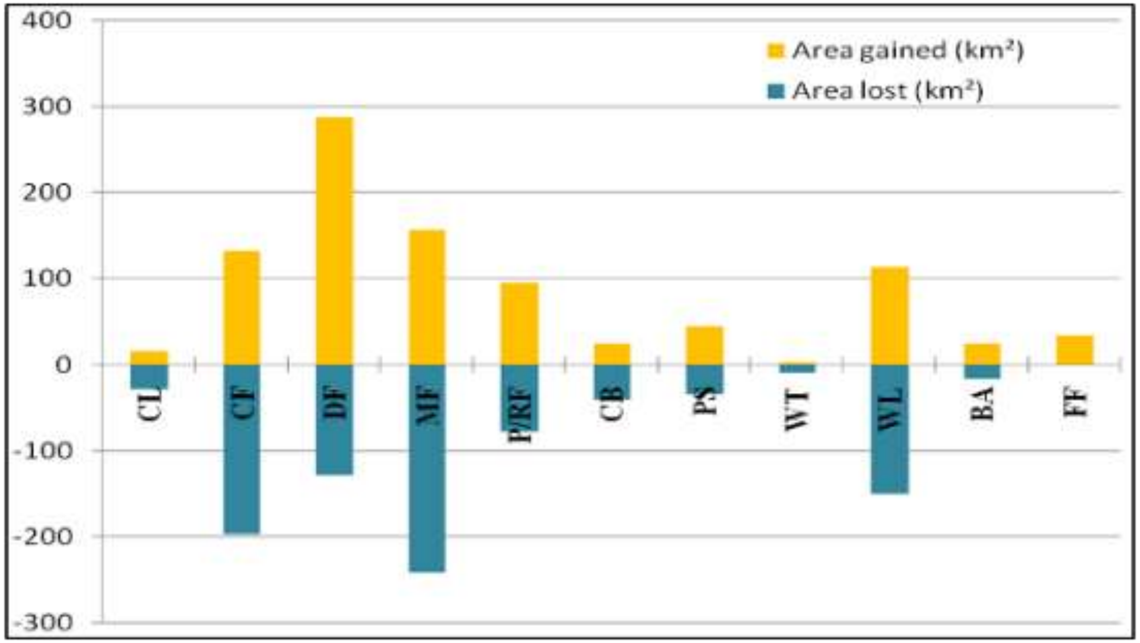
The matrix multiplies as number of classes increase

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

Recent UNBC M.Sc thesis – supervised classifications 1984 and 2010 Watershed SW of Vanderhoof



	1984		1999		2010	
LULC type	**km^2**	**% of total**	**km^2**	**% of total**	**km^2**	**% 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 Landsat images