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

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

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. Use digital analysis algorithms

Google Earth Time Lapse 1984-2016

33 years of Landsat images; 55,000 images - 1 petabytes of data

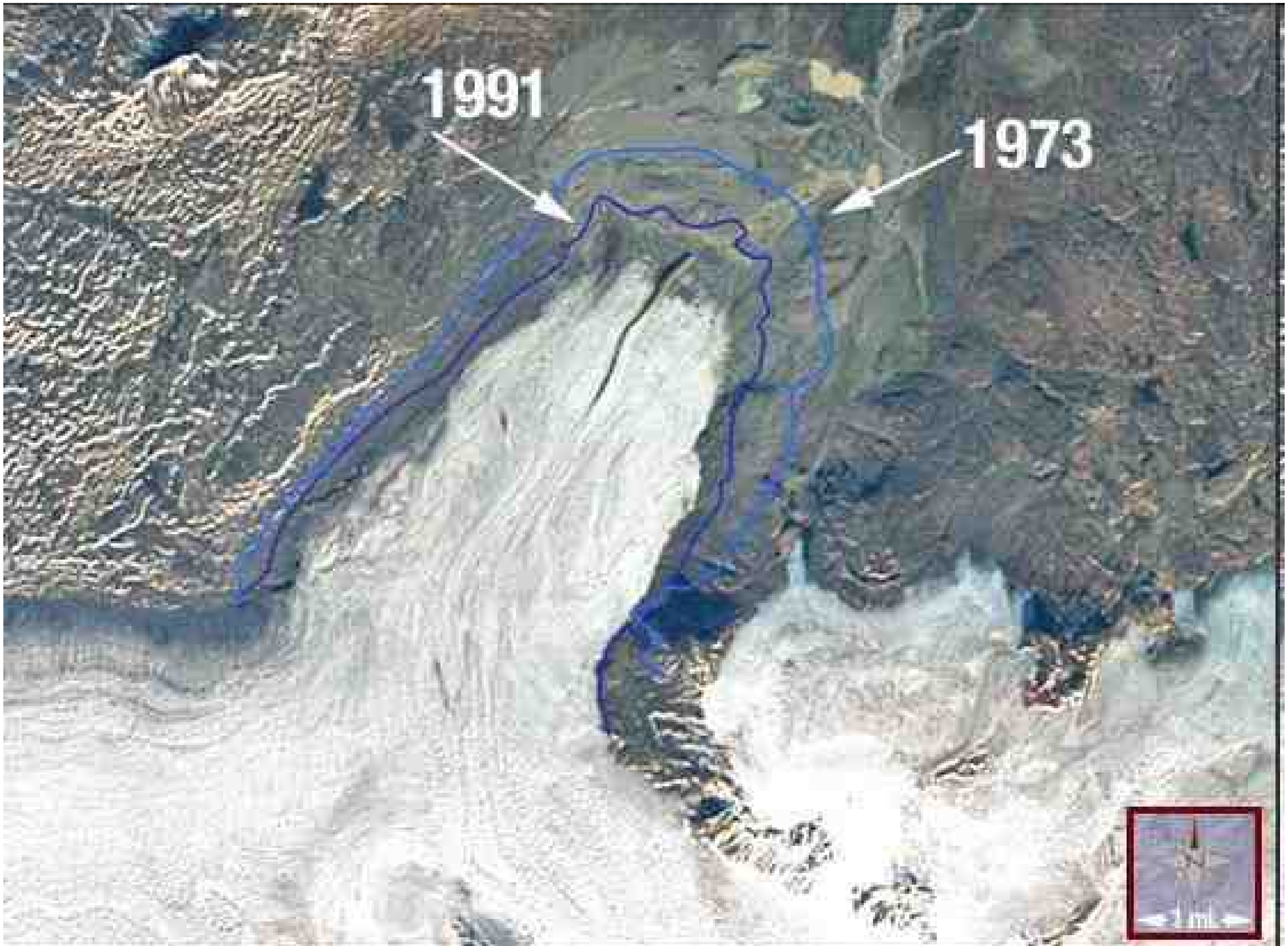
https://earthengine.google.com/timelapse/

Note: mountain areas comparison are less effective due to seasonal snow

Ft. MacMurray:

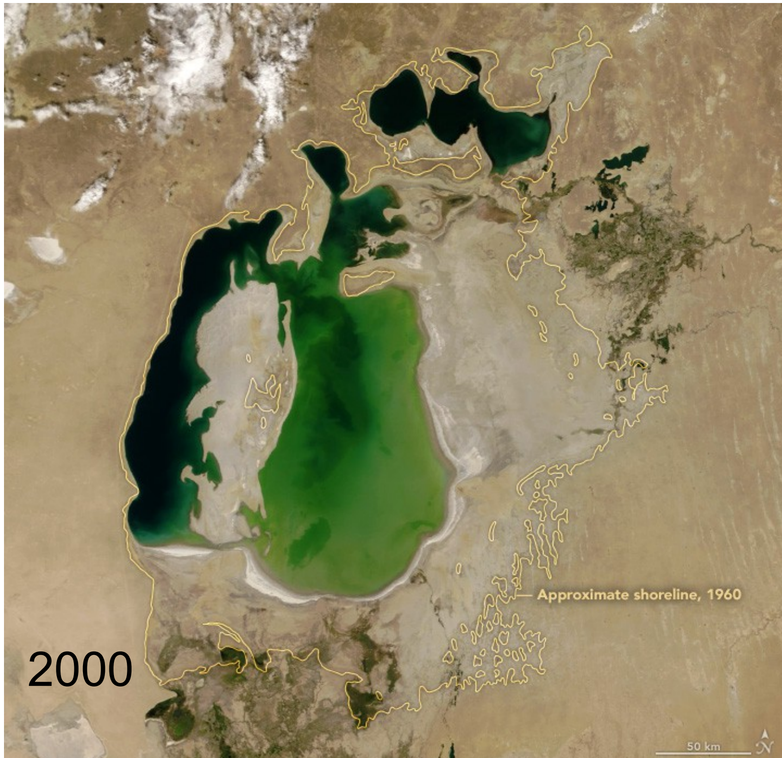
https://www.smithsonianmag.com/smart-news/google-earths-new-tools-shows-32-years-changing-planet-180961251/

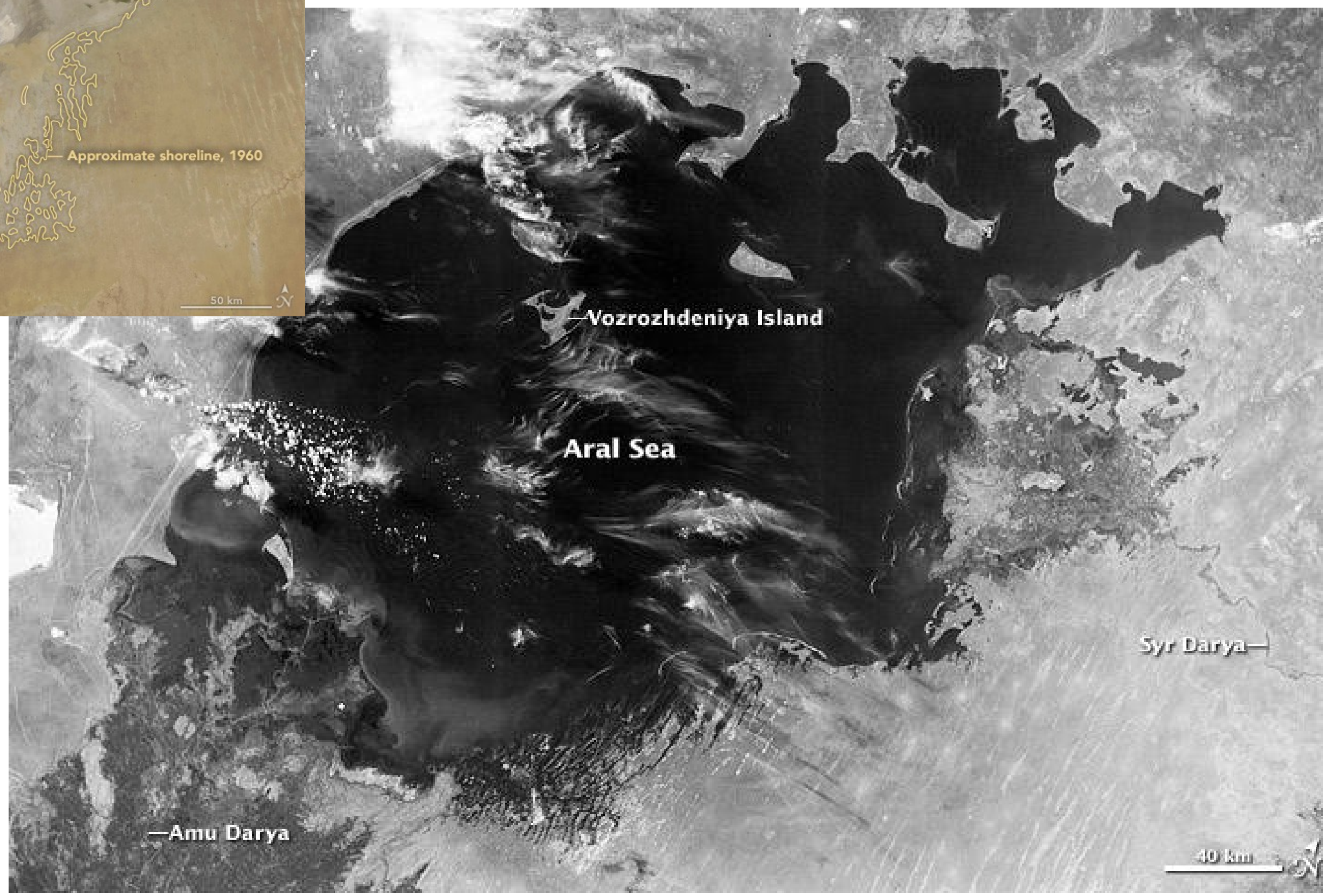
Digitised features: Eyjabakkajökull, Iceland



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

Aral Sea 1964 from Corona spy satellite





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

Image sequences for change detection

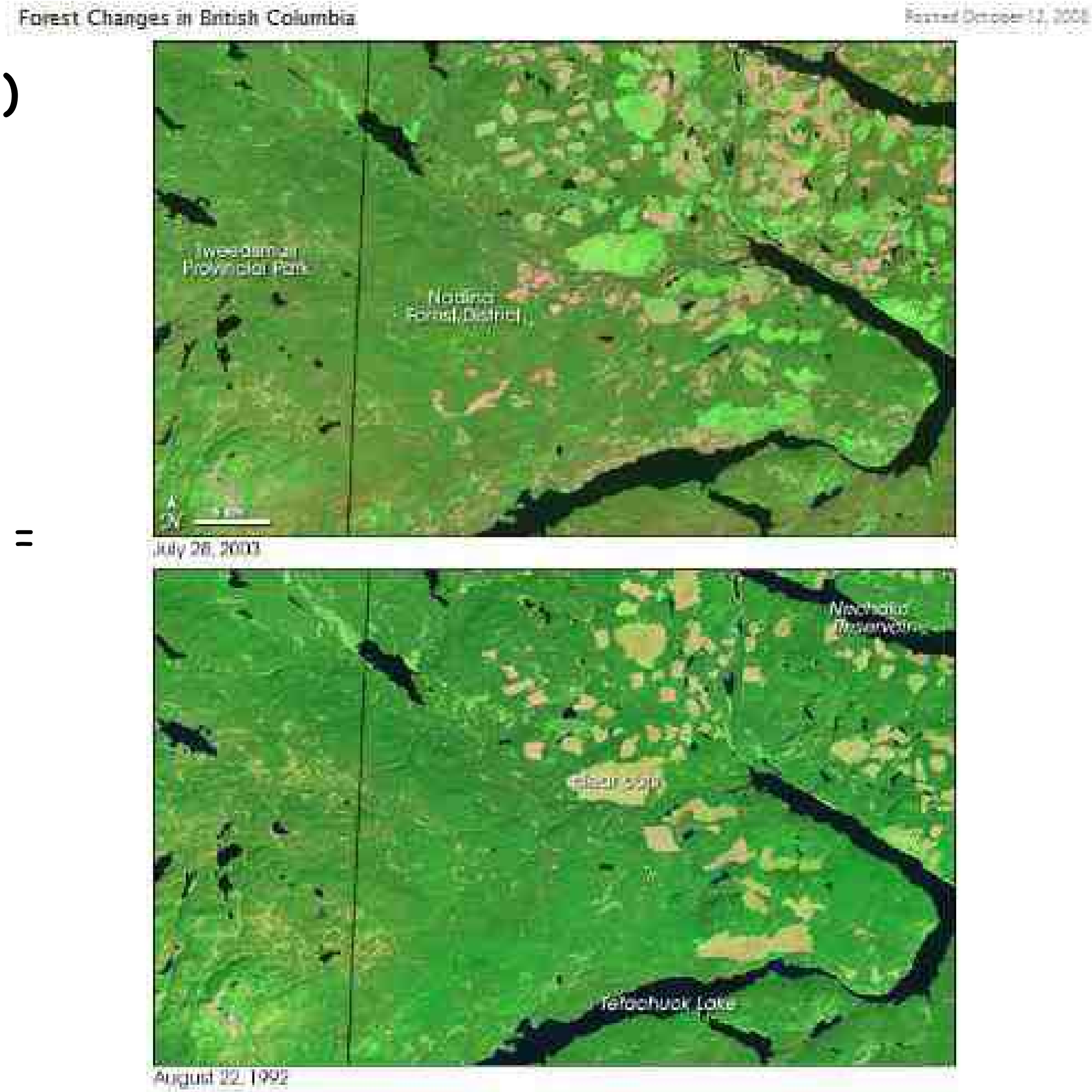
Ground photos/balloons	1850 ->
Air photos	1920 ->
Landsat MSS (80m)	1972 -> 1992 -> 2012
Landsat TM (->ETM+ / OLI)	1984 → 2002-> 2020
AVHRR (1km) NDVI	1979 ->
High resolution (1 m)	2000 ->

Ground photos: http://explore.mountainlegacy.ca/captures/4338/comparisons

Landsat (since 1972)

Satellite imagery

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



Example from Landsat 5

Change monitoring Considerations 1

Timing (day/year)

- Time of <u>day</u> affects horizontal sun angle (azimuth)

  ... consistent with Landsat and other satellites

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

- Seasonal ground cover – vegetation, snow, crops

- Seasonal phenology – can change by ±2 weeks each year

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

Answer: ?

1993- PG map

Issues: time of day and year, shadows, media

2003

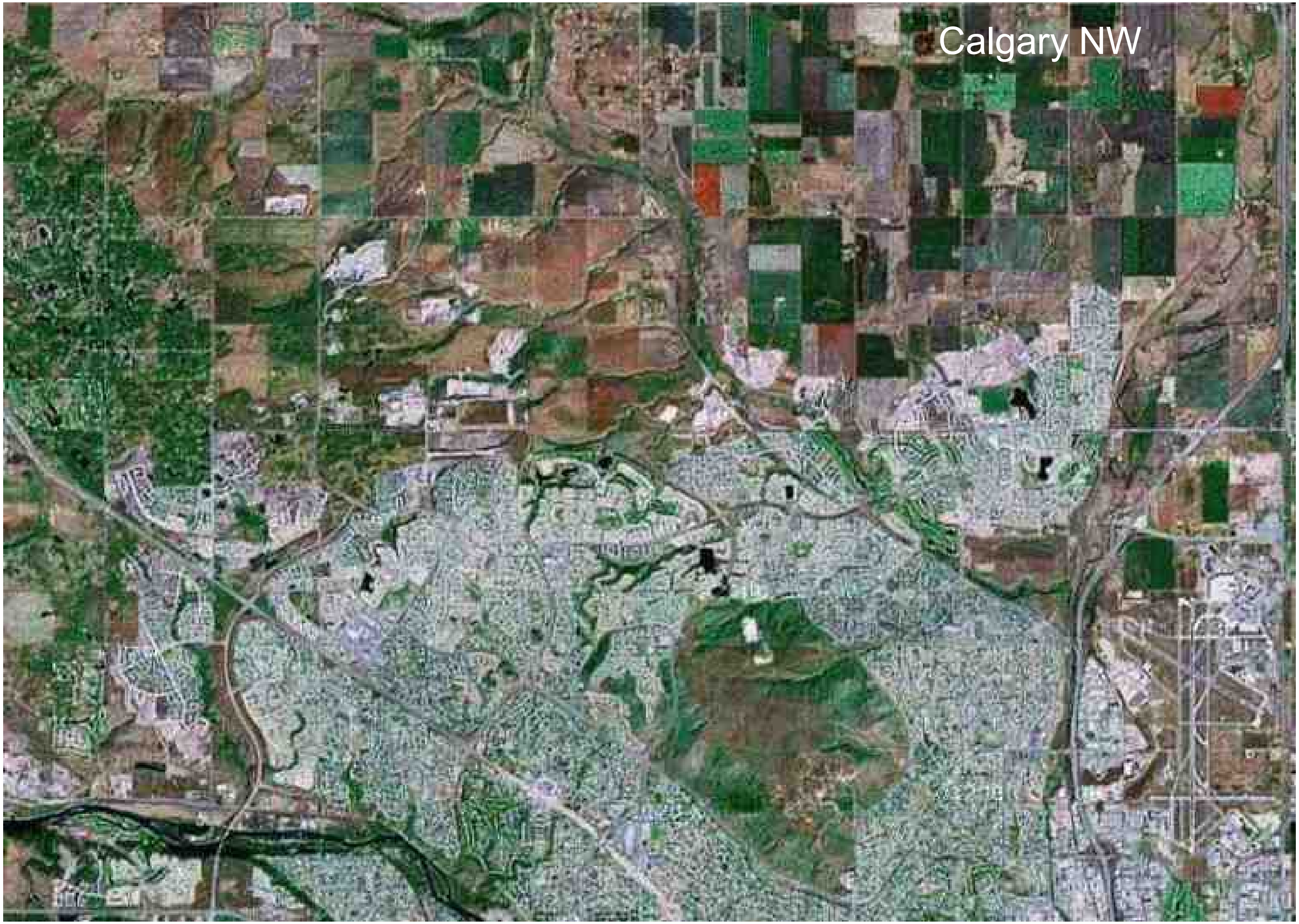
UNBC 2006

Change monitoring considerations 2

Frequency / type of Changes

- short term versus long term e.g. lakes, snow, crops, harvesting
- local versus global e.g. retreat of arctic ice, desertification
- gradual versus catastrophic – e.g. soil slip v landslide
- cyclical changes – urban and forest examples (next slide)

Urban development cycle: clearing, subdivision …landscaping, maturity



Crop / vegetation cycles: seasons/phases: clearing, planting, growth, maturity, harvest

Change monitoring Considerations 3

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: **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

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 are important for visual comparisons of RGB composites, but <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
- **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

Prince George example (band 3):

2003 (B) July 22

2004 (G) Aug 9

2005 (R) Aug 19

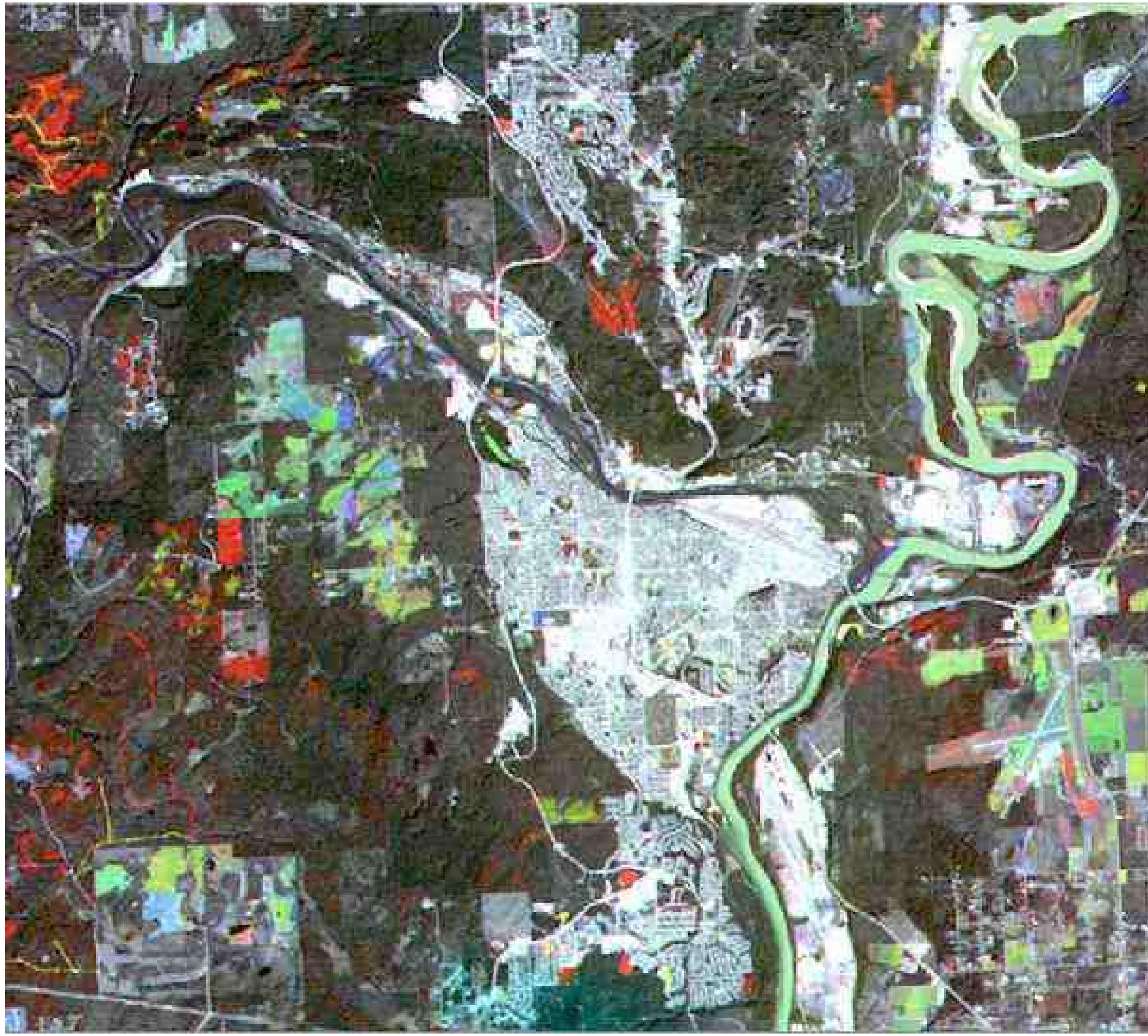
Impact of reflection change

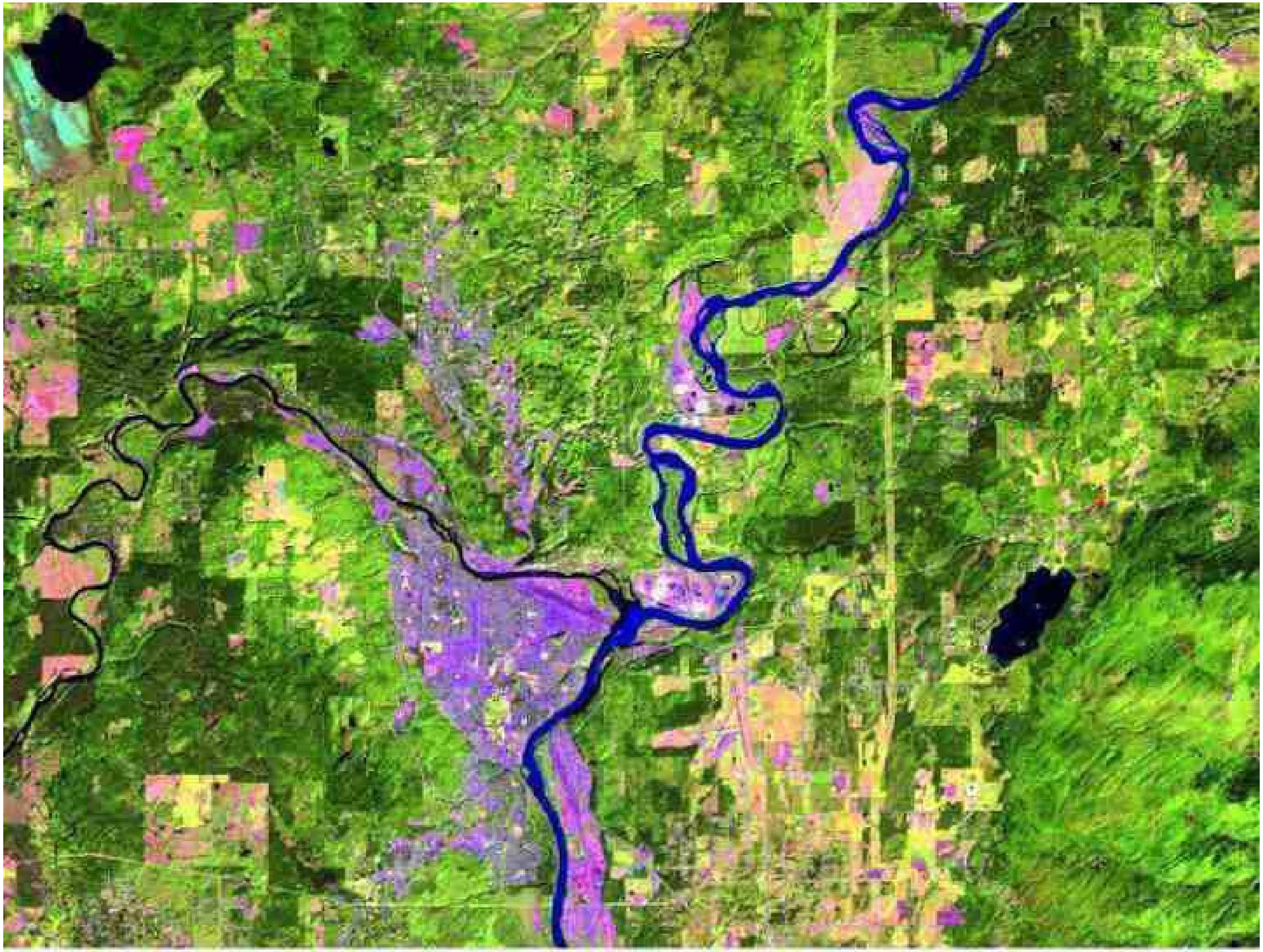
Increase = more red (Areas cleared)

Decrease = blue (regrowth)

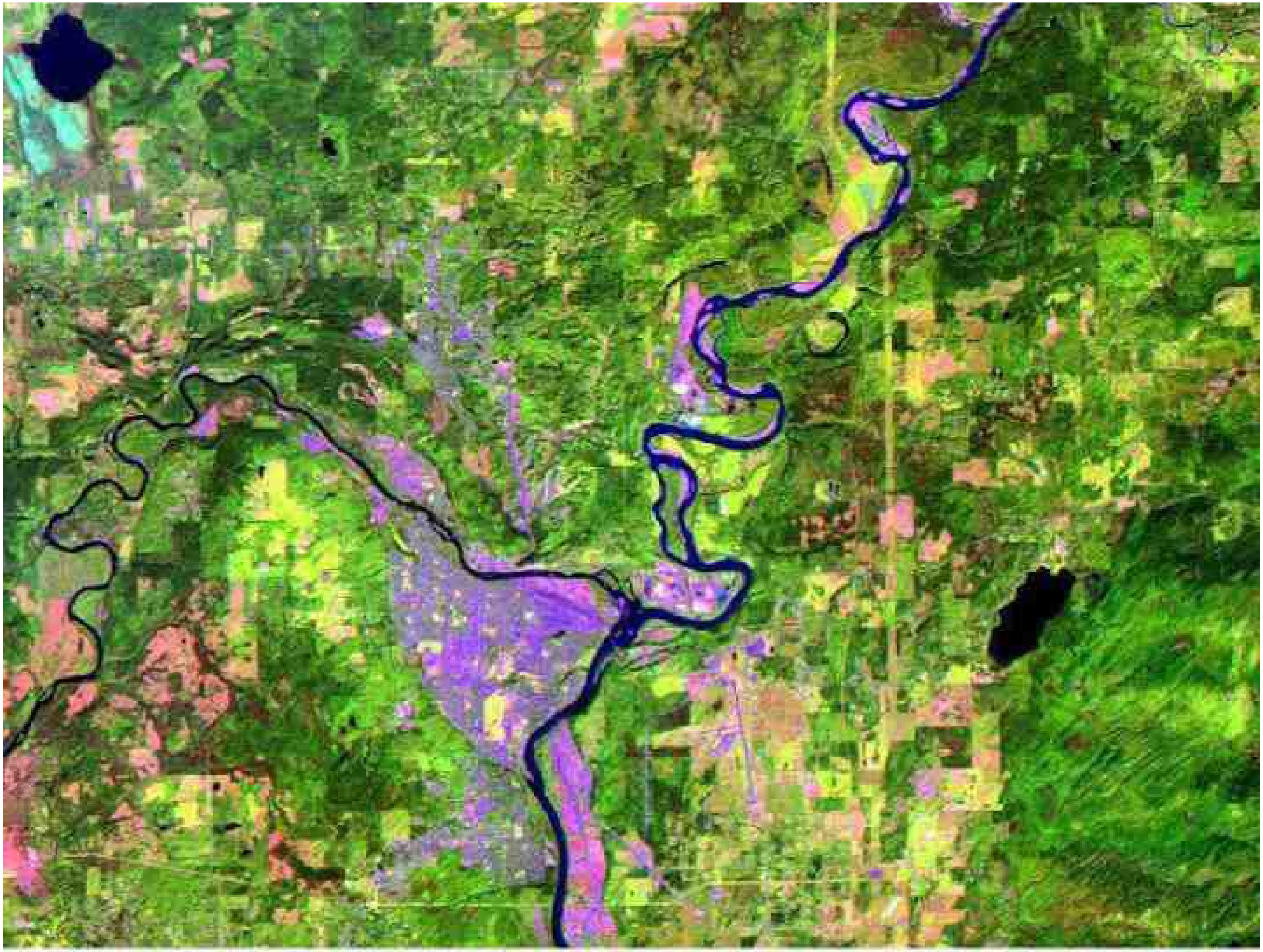
No change = grayish

Seasonal: fields, river





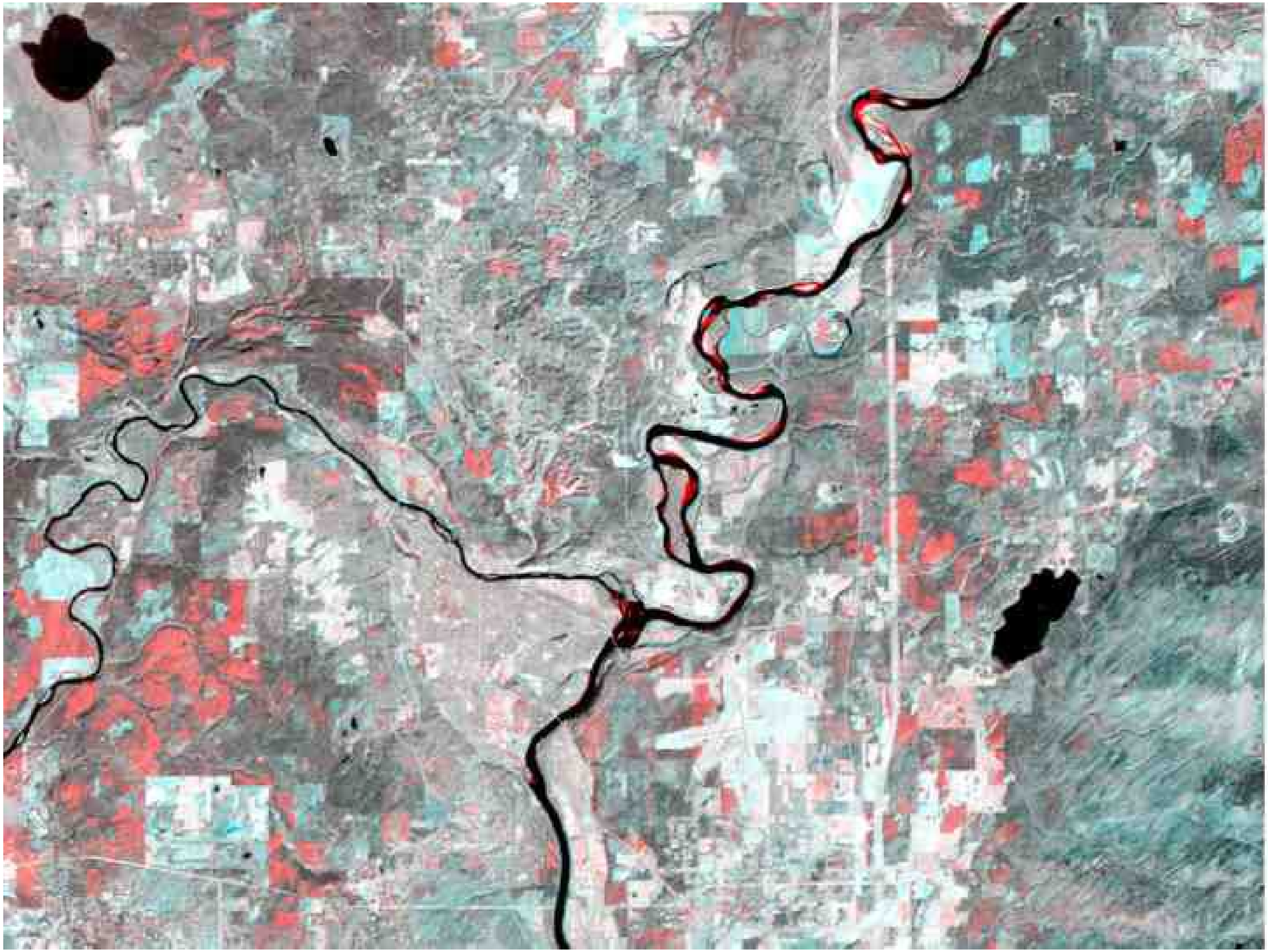
1996



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

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

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

2. Image algebra - differencing

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

No change = ~ 0

Change = +ve or –ve

Evaluate meaning of + versus - (threshold)

Output to 8 bit, or 16 bit **signed** channels ?

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

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

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

- These numbers below indicate ability to compare (?) as they are fairly similar especially IR bands

Band	1998	sd	2009	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 tasseled cap - would the DNs increase or decrease ?

- Brightness ?
- Greenness ?
- Wetness ?
- NDVI (or 4/3 ratio)

Change detection and mapping – digital methods

Example (Tasmania):

New plantations mapped by subtracting NDVI 1992-1999

http://gis.unbc.ca/courses/geog432/projects/2006/pulling/index.htm

UNBC Geog432 project:

1992-1997 forest clearance

Fig.1. Colour composite using bands 3,4 and 5 from   Fig. 2.Colour composite using bands 3,4 and 5 from 1997

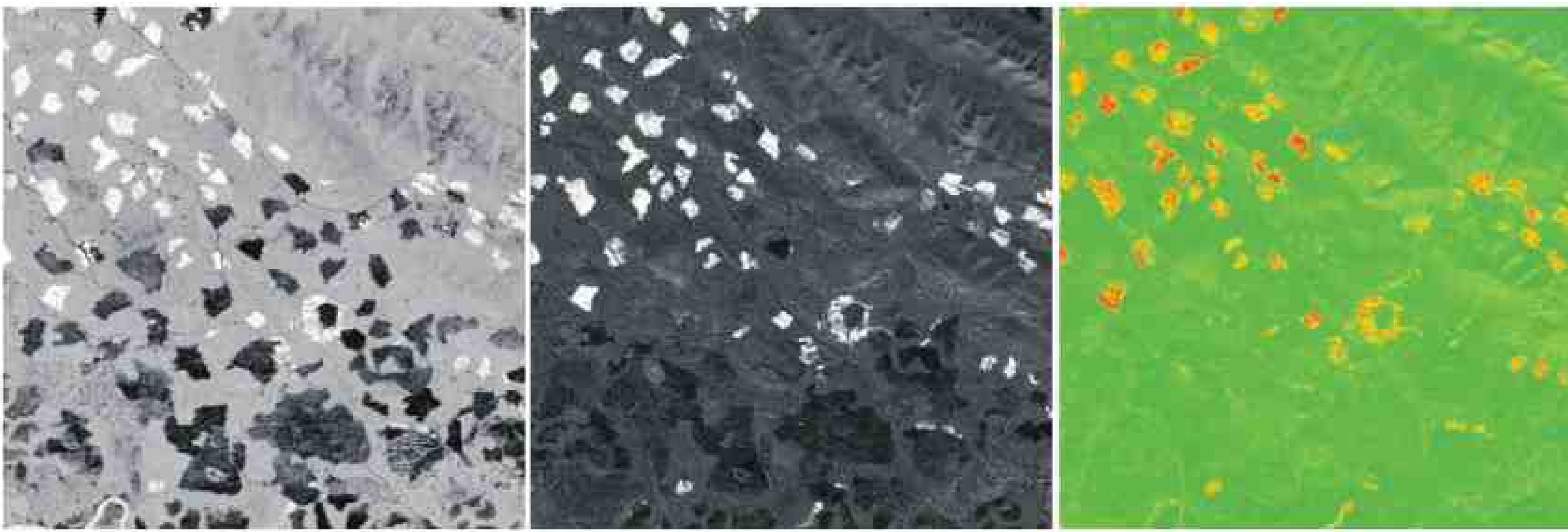
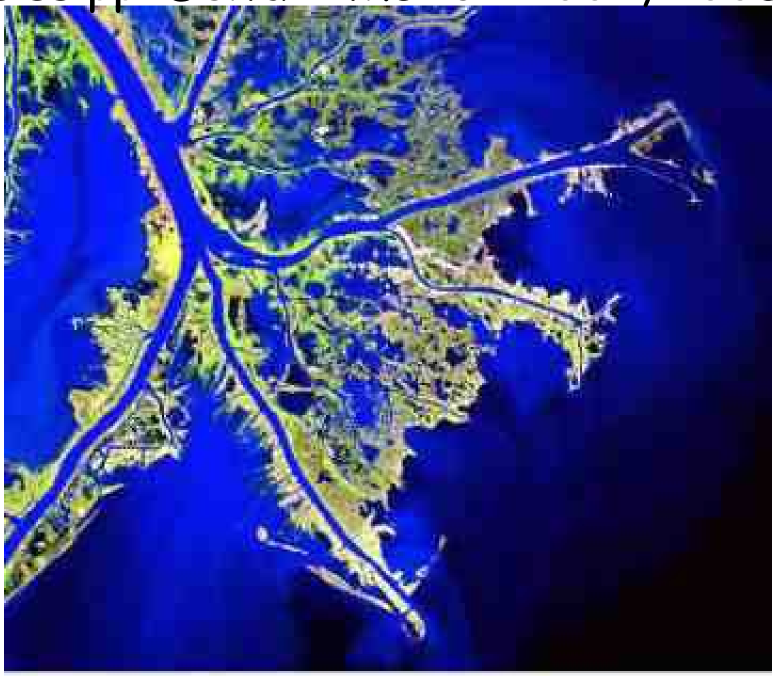


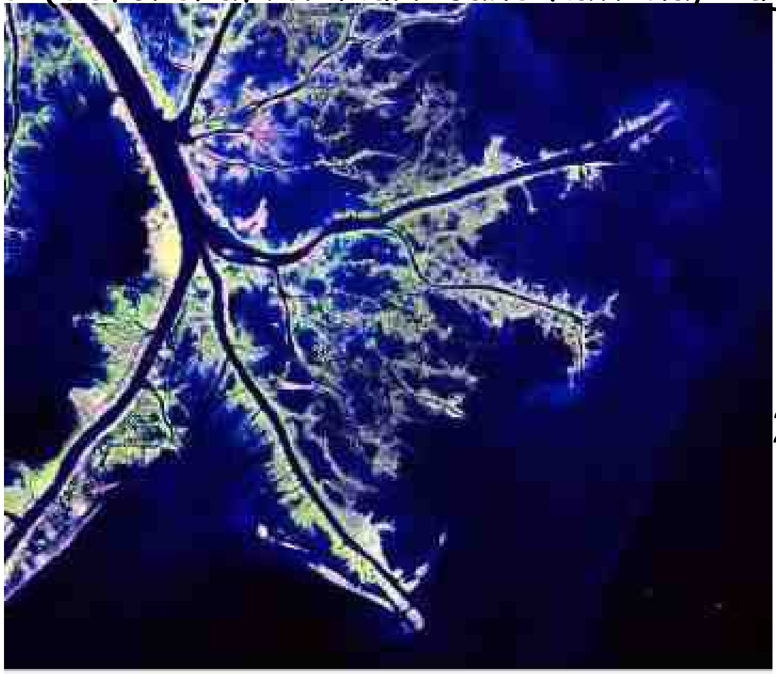
Fig. 3, 4 and 5. Tasseled Cap Wetness subtraction, PC2 and a pseudocolour display of the NDWI image subtraction respectively. Deforested areas are white in figures 3 and 4 and red in figure 5. Black areas were harvested prior to 1992.

1992-97 cutblock size has decreased

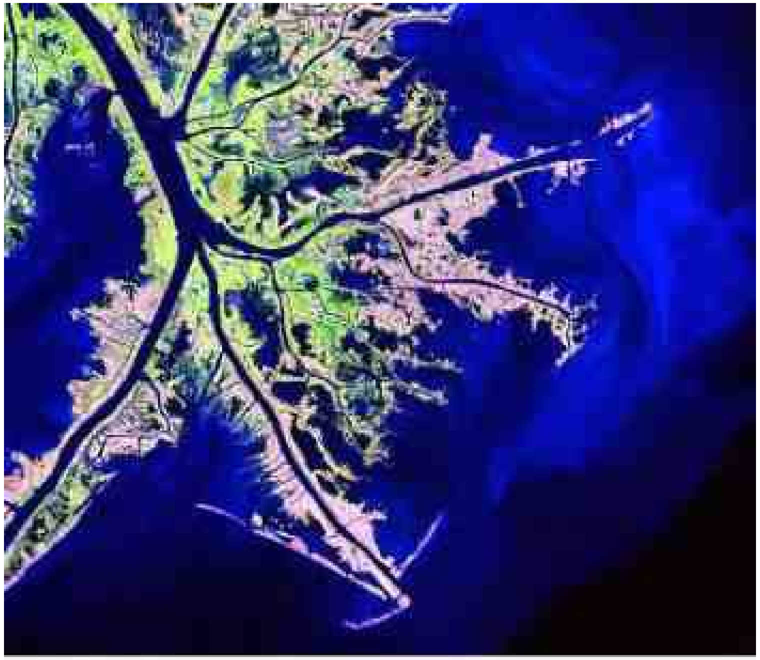
Mississippi Delta: TM543: 2004, 2005, 2010 (before/after Hurricane Katrina, Aug 2005)



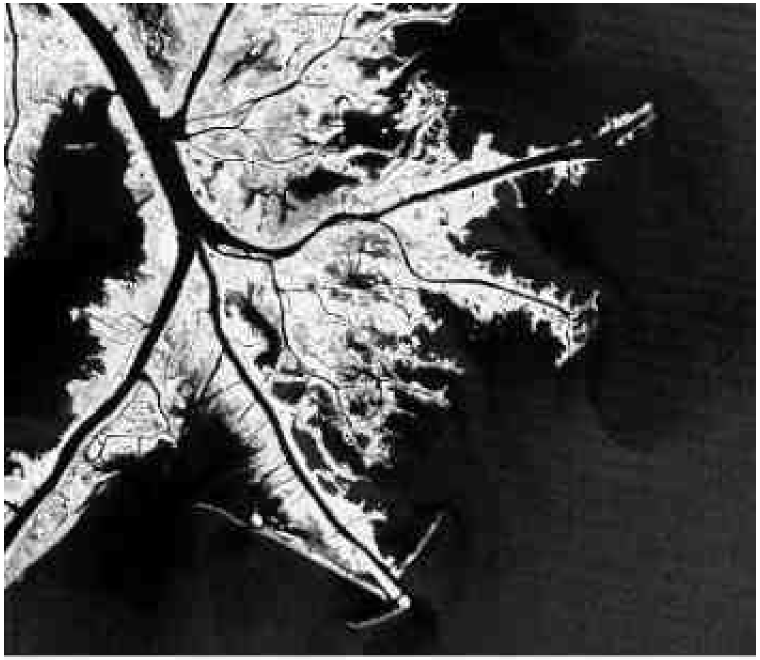
2004



2005

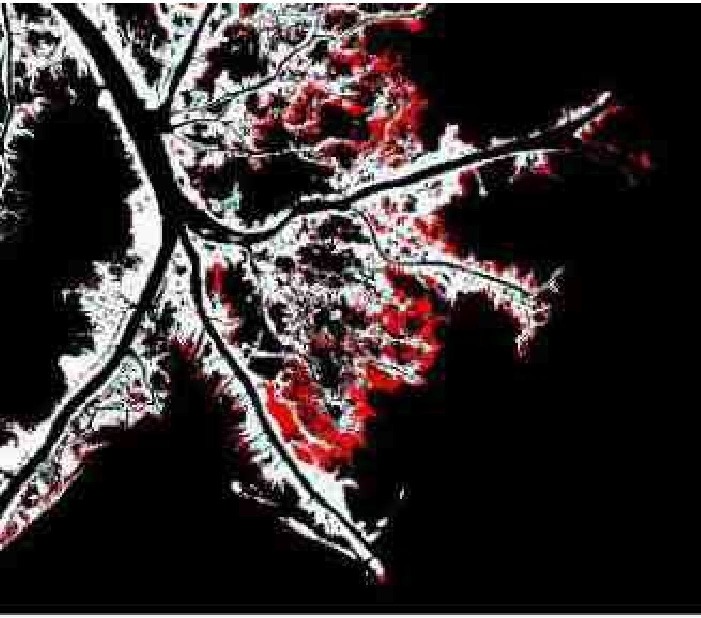


2010

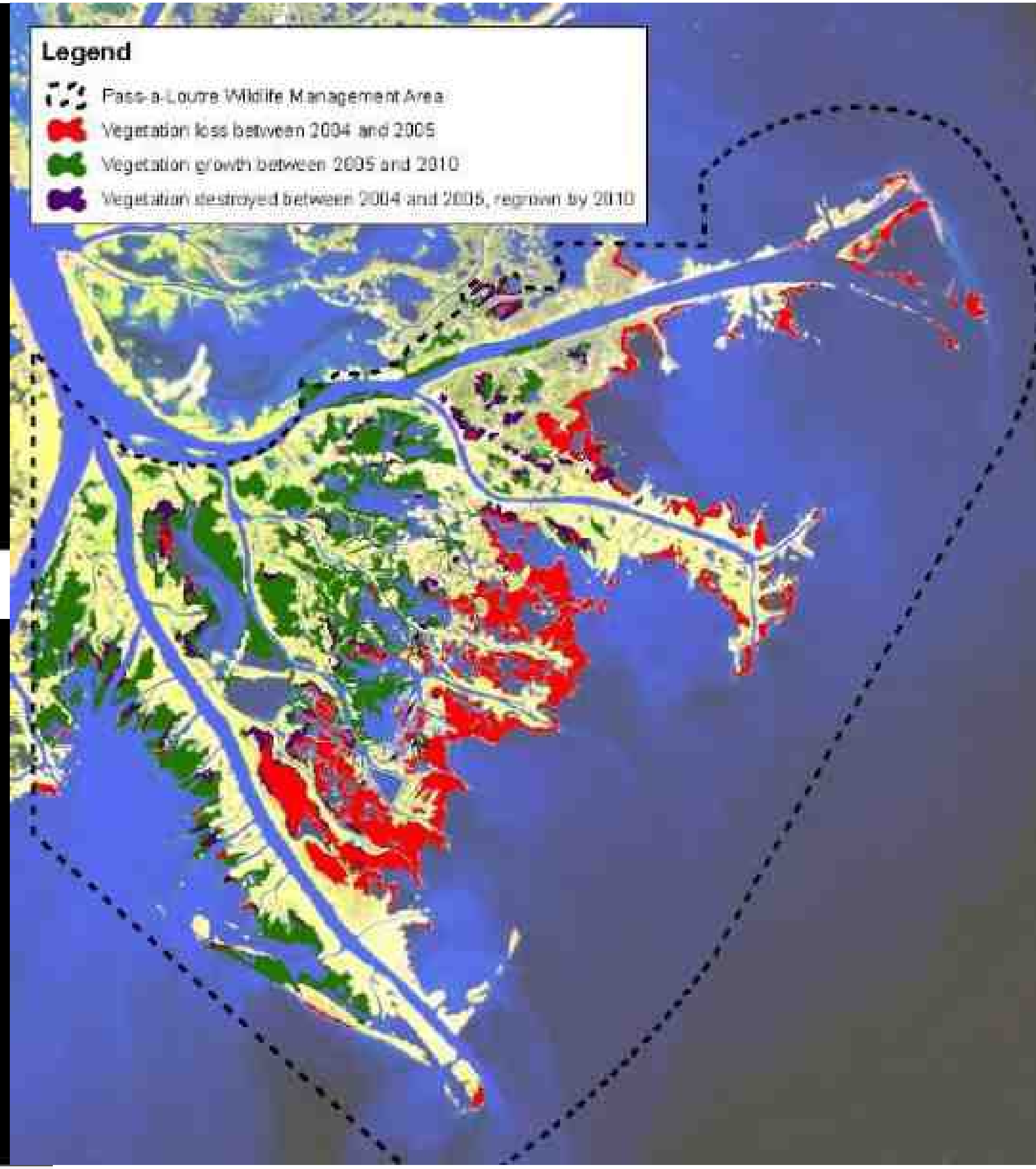


NDVI
2010

NDVI difference 2004-5



NDVI difference 2005-10



3. Post classification comparison: the 'matrix'

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

Time A

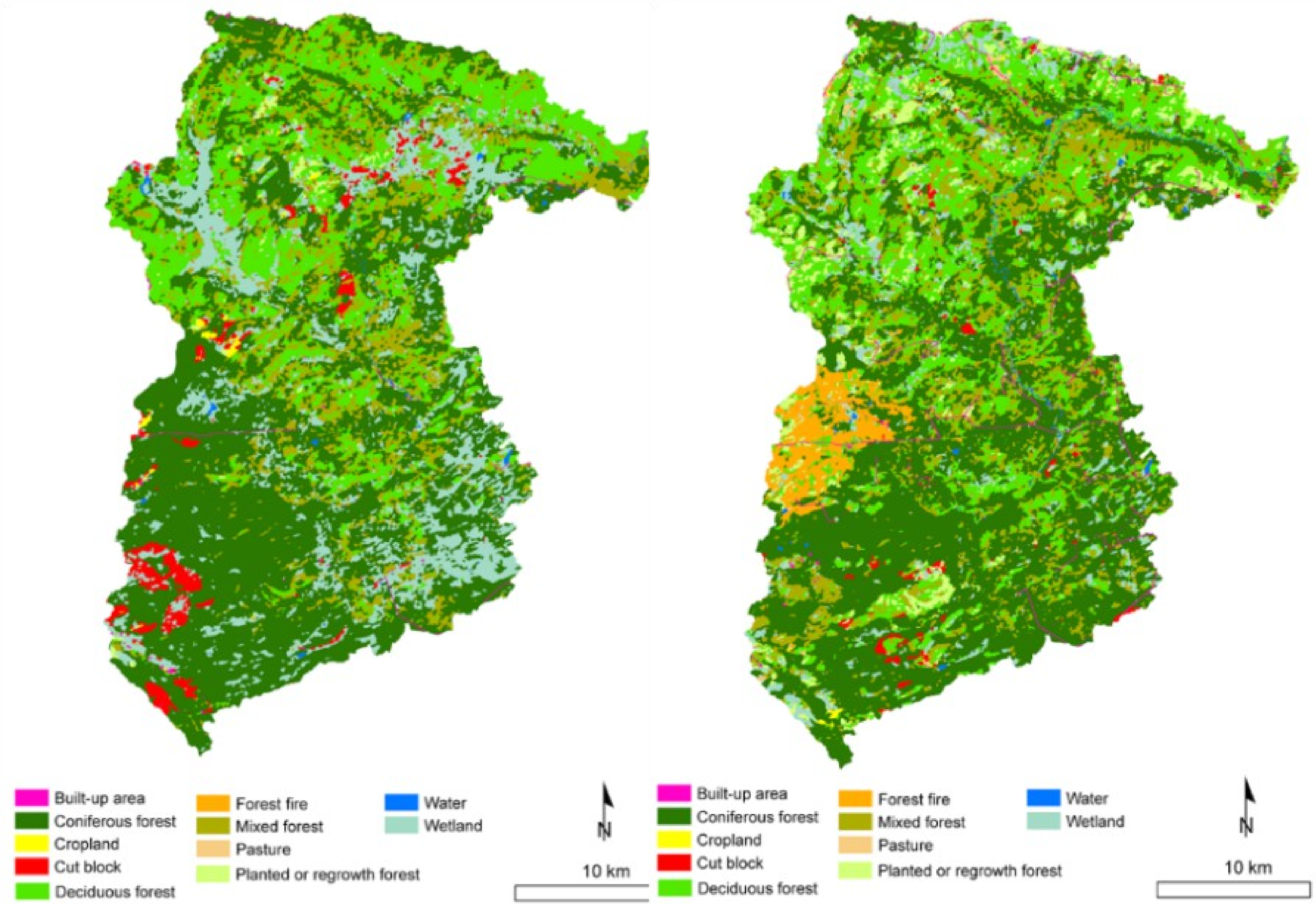
	Water	Cropland	Rangeland	Forest	Total
Water	2842	3	4	0	2849
Cropland	1	31874	596	0	32471
Rangeland	2	1063	72487	23	73575
Forest	0	8742	328	53221	62291
Total	2845	41682	73415	53244	171186

Time B

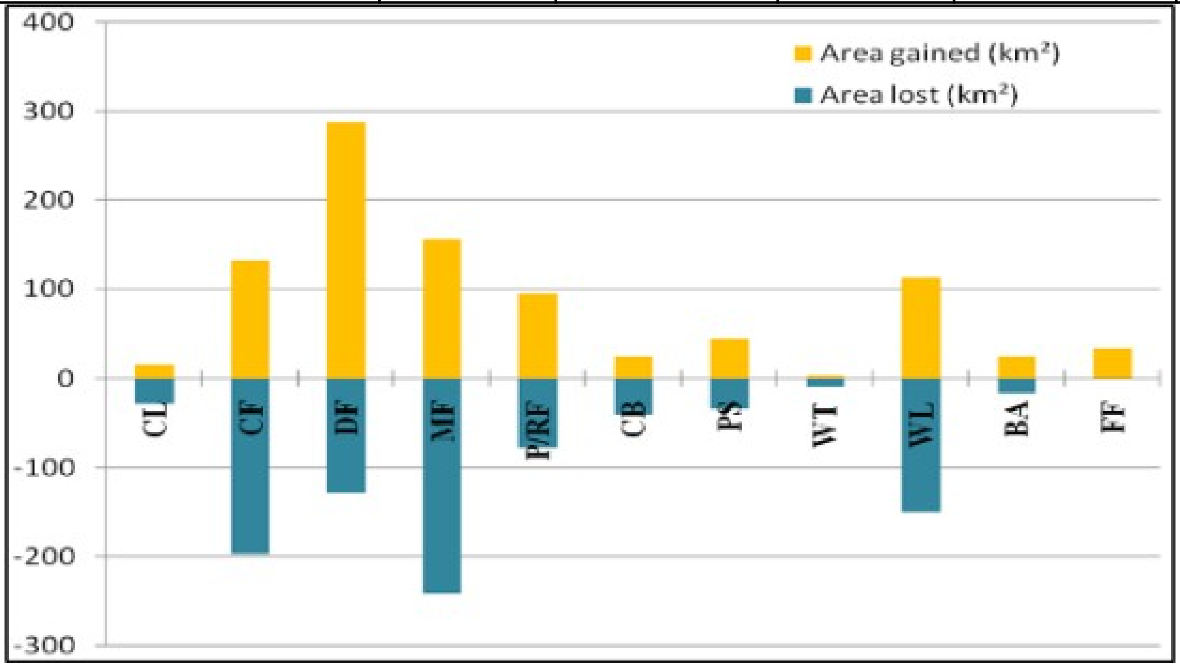
The matrix multiplies as number of classes increase

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

Recent UNBC M.Sc thesis – supervised classifications 1984 and 2010

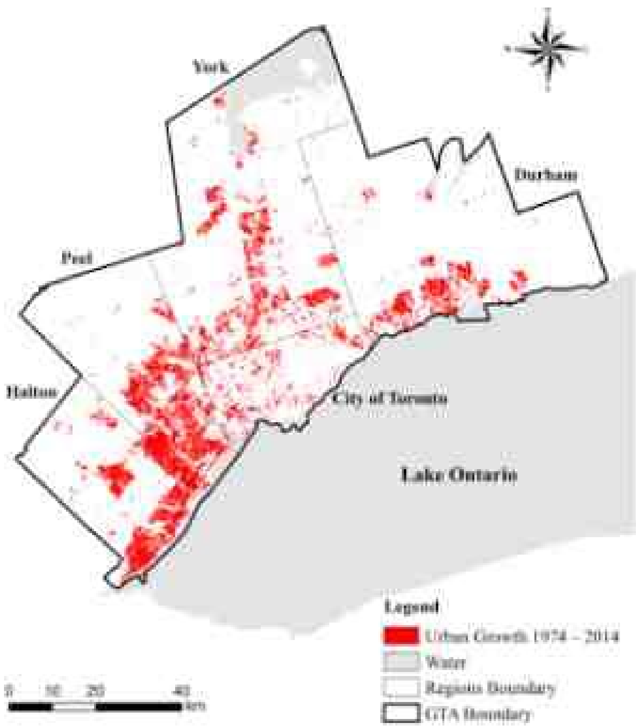


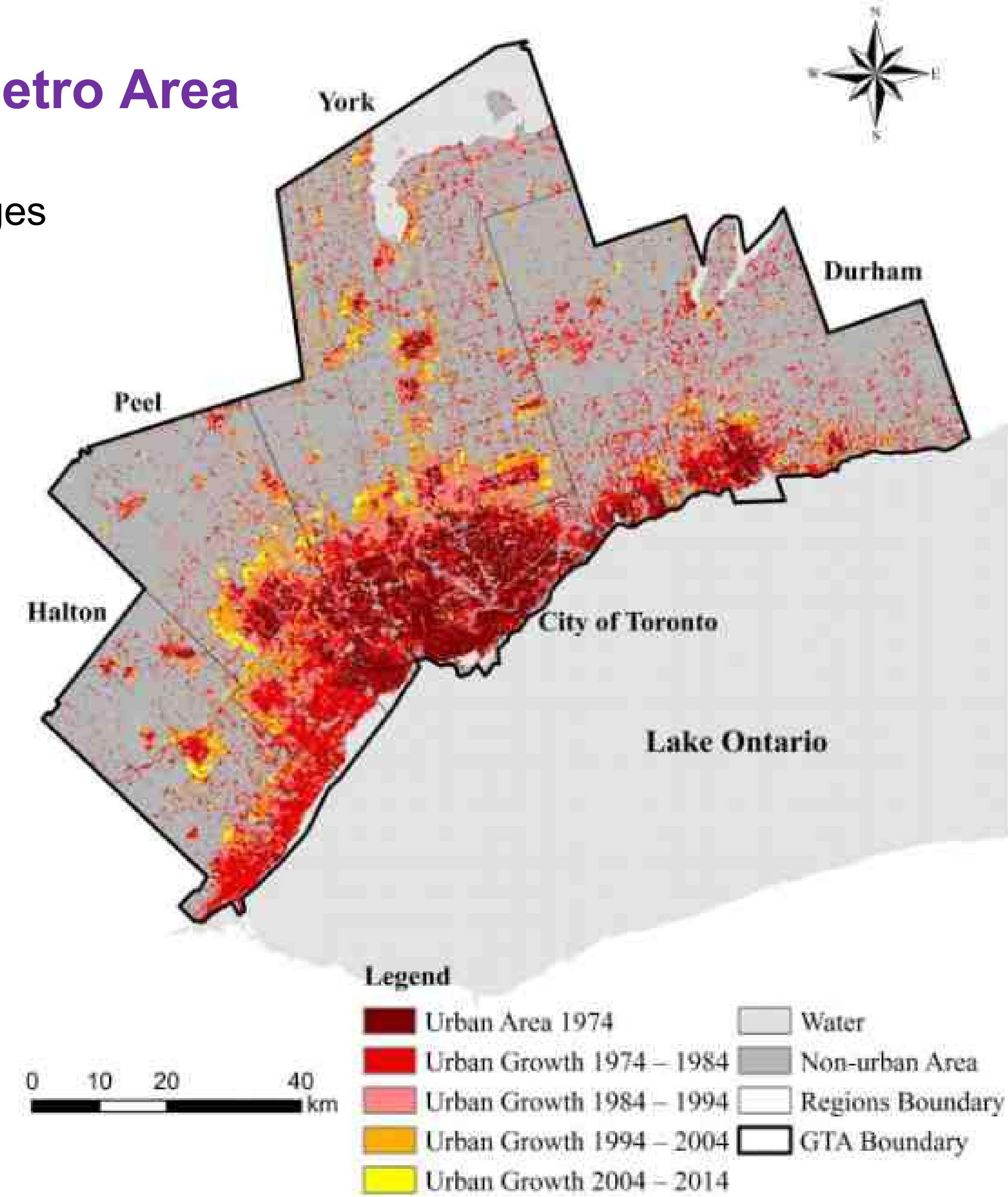
	1984		1999		2010	
LULC type	**km²**	**% of total**	**km²**	**% of total**	**km²**	**% of total**
Cropland (CL)	23.27	0.82	31.70	1.12	18.82	0.66
Coniferous forest (CF)	1059.06	37.35	1175.45	41.45	1107.84	39.05
Deciduous forest (DF)	796.65	28.09	660.79	23.30	815.34	28.83
Mixed forest (MF)	351.97	12.41	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 Landsat images





Summer job posting

Sr. Resource Management Position

Projects planned for 2021 include:

- Forest Assessments
- Harvest Site Planning including partial cutting
- Installation and re-measurement of various research trials and ecological studies
- Hosting of various tours and educational events

Aleza Lake Research Forest

Details:

http://alrf.unbc.ca