Change detection

Using repeat images from different time periods

a. View side by side and/or with slider

b. In sequence (animation)

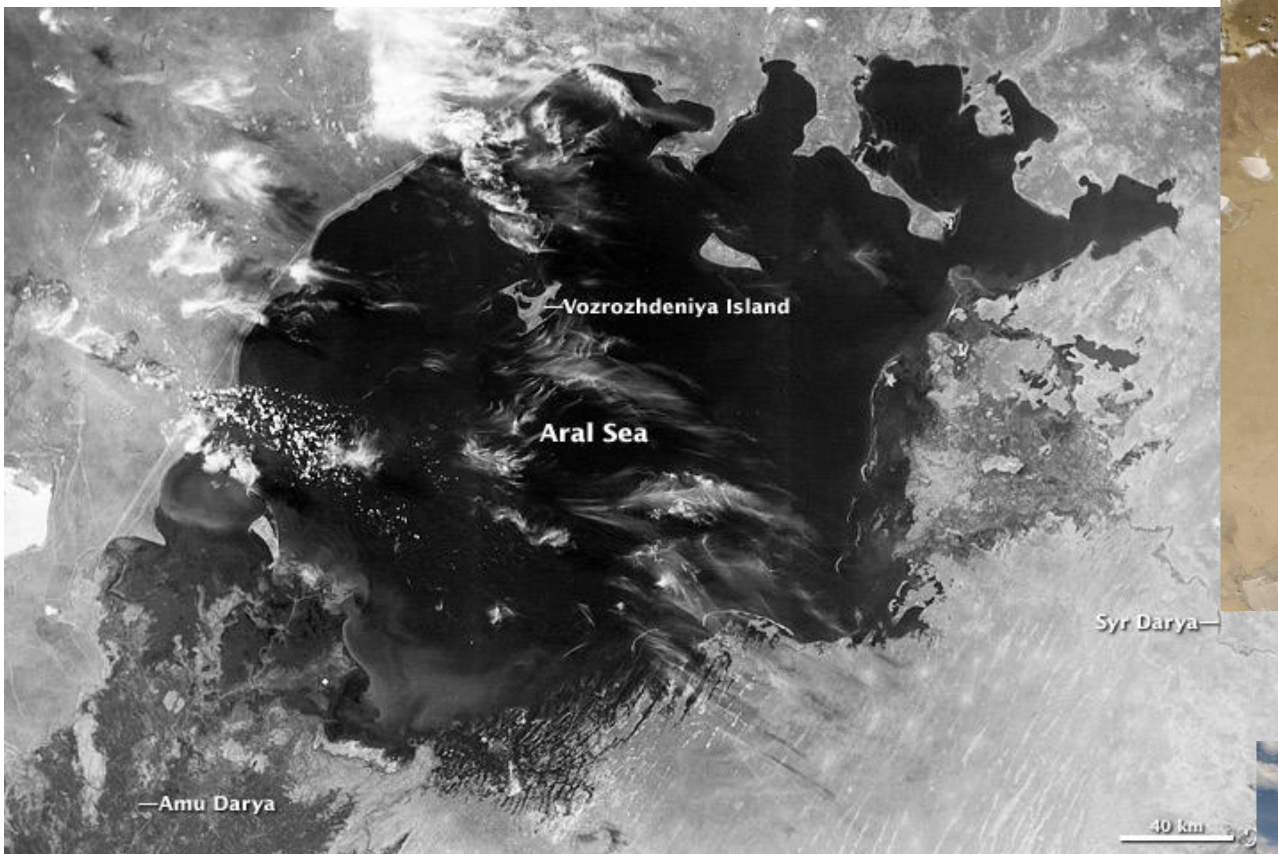
c. Digitise features /overlay

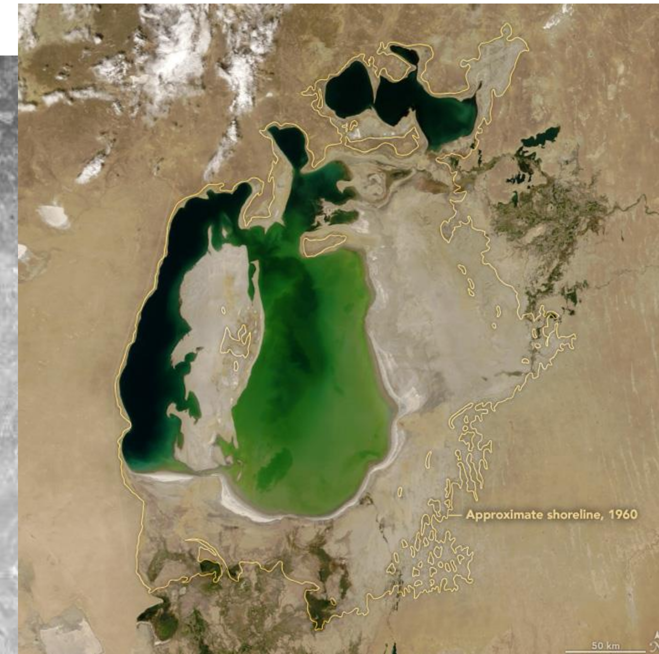
d. Use digital analysis algorithms

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

Animation: 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

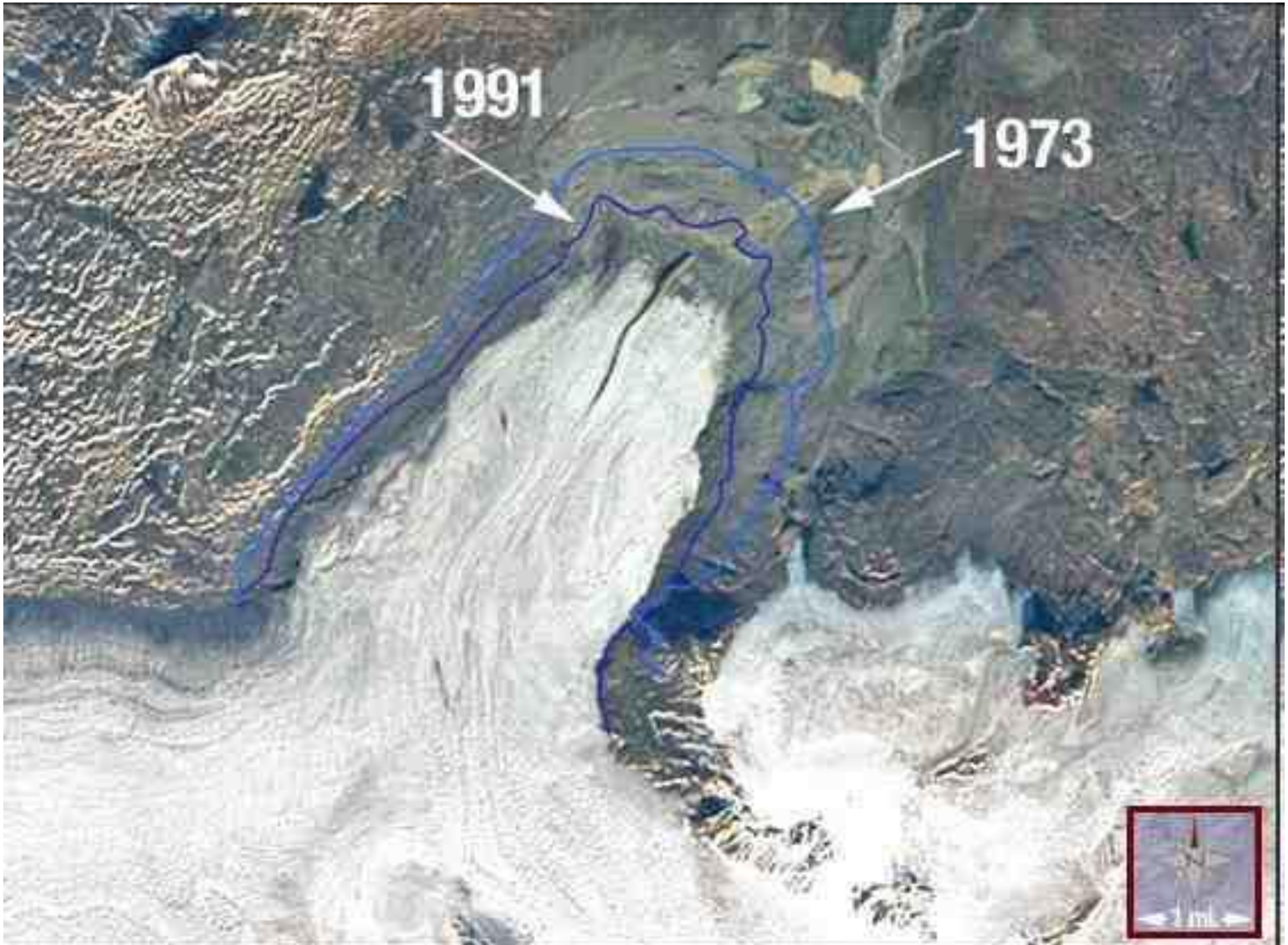
Before and after aerial photographs -
Brisbane Floods, Australia, January 2011

5 years on …
https://www.abc.net.au/news/2016-01-13/brisbane-floods-2011-before-after-2016/7080640

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 ->

Digitised features: Eyjabakkajökull, Iceland



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

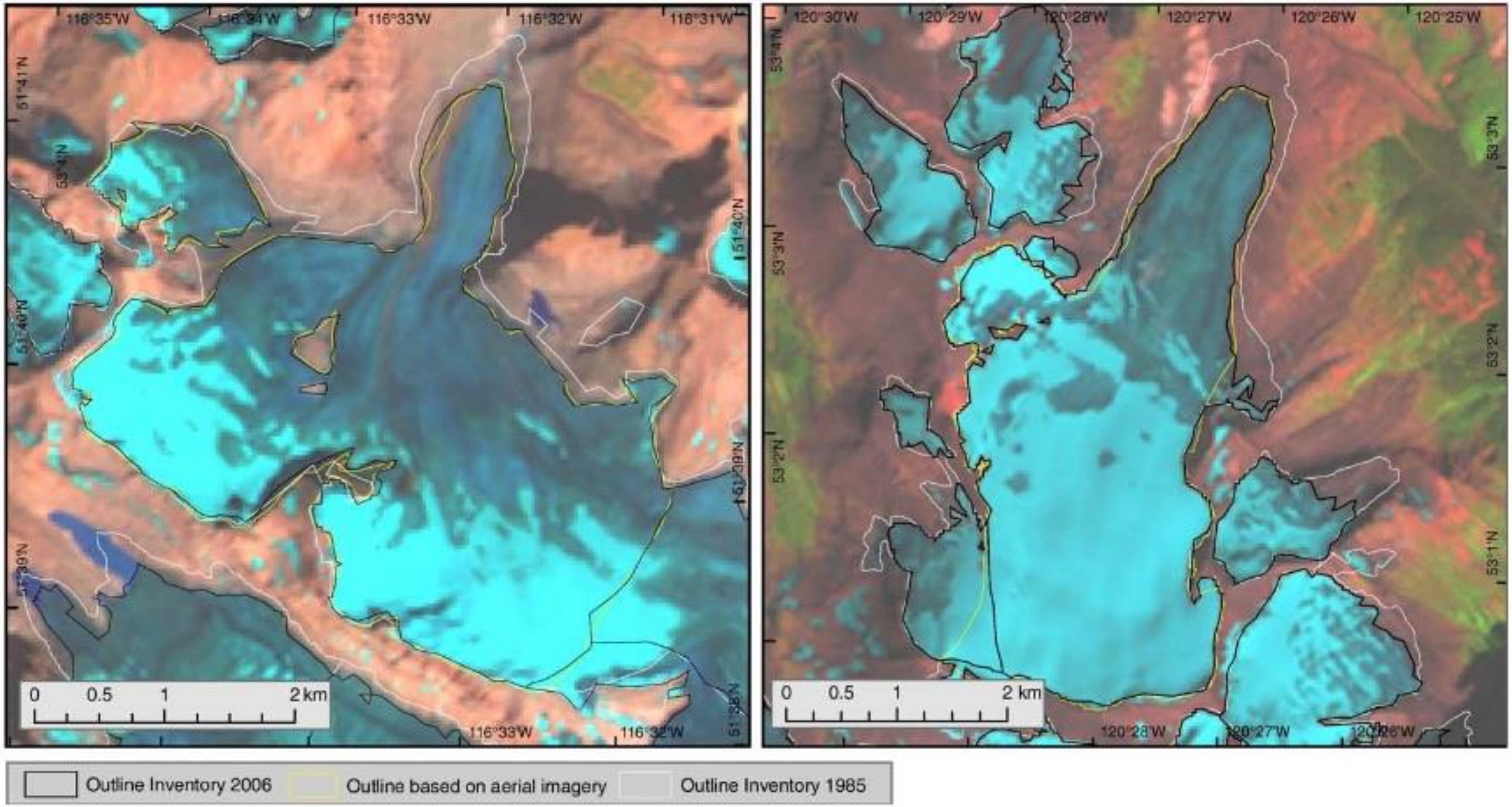


Fig. 4. Deviation of glacier outlines digitized manually from high resolution aerial photography (Matt Beedle, pers comm., 2007) and derived from Landsat TM data using our automated approach; left: Peyto Glacier in the southern Rocky Mountains, right: Castle Creek Glacier in the southern Interior Ranges;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

Change monitoring Considerations 1

Timing (day/season) from Env Change lecture

- 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

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

Change monitoring considerations 2

Frequency / type of Changes - from Env Change lecture

- 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)
b. Illumination (angle of reflection)
c. **Albedo (response to surface cover)**

Change monitoring Considerations 3

Environmental

- **atmospheric conditions** e.g. haze
- **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 impact 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

- **Classified images**

Digital algoritms
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

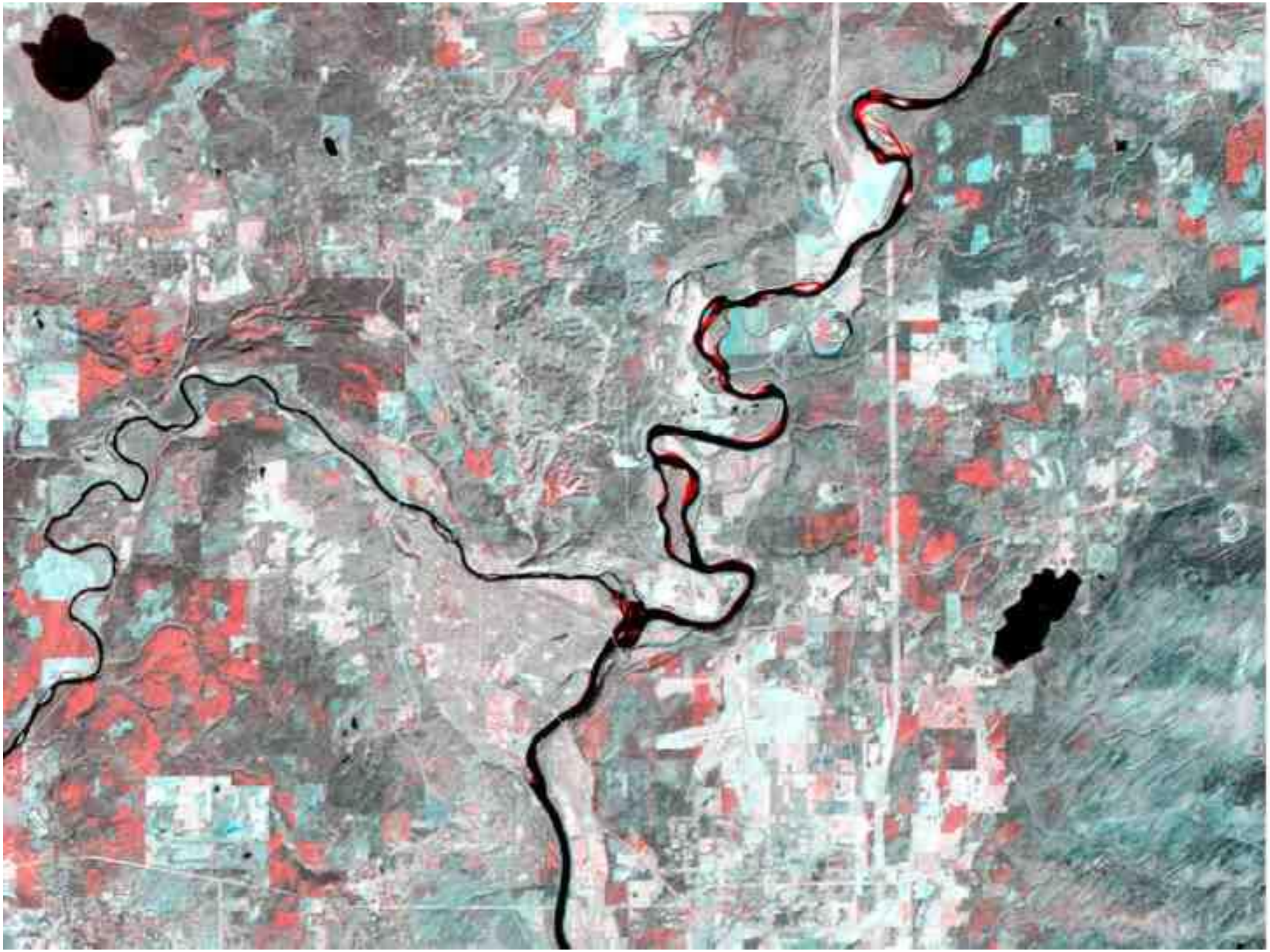
Increase = more red (Areas cleared)

Decrease = blue (regrowth)

No change = grayish

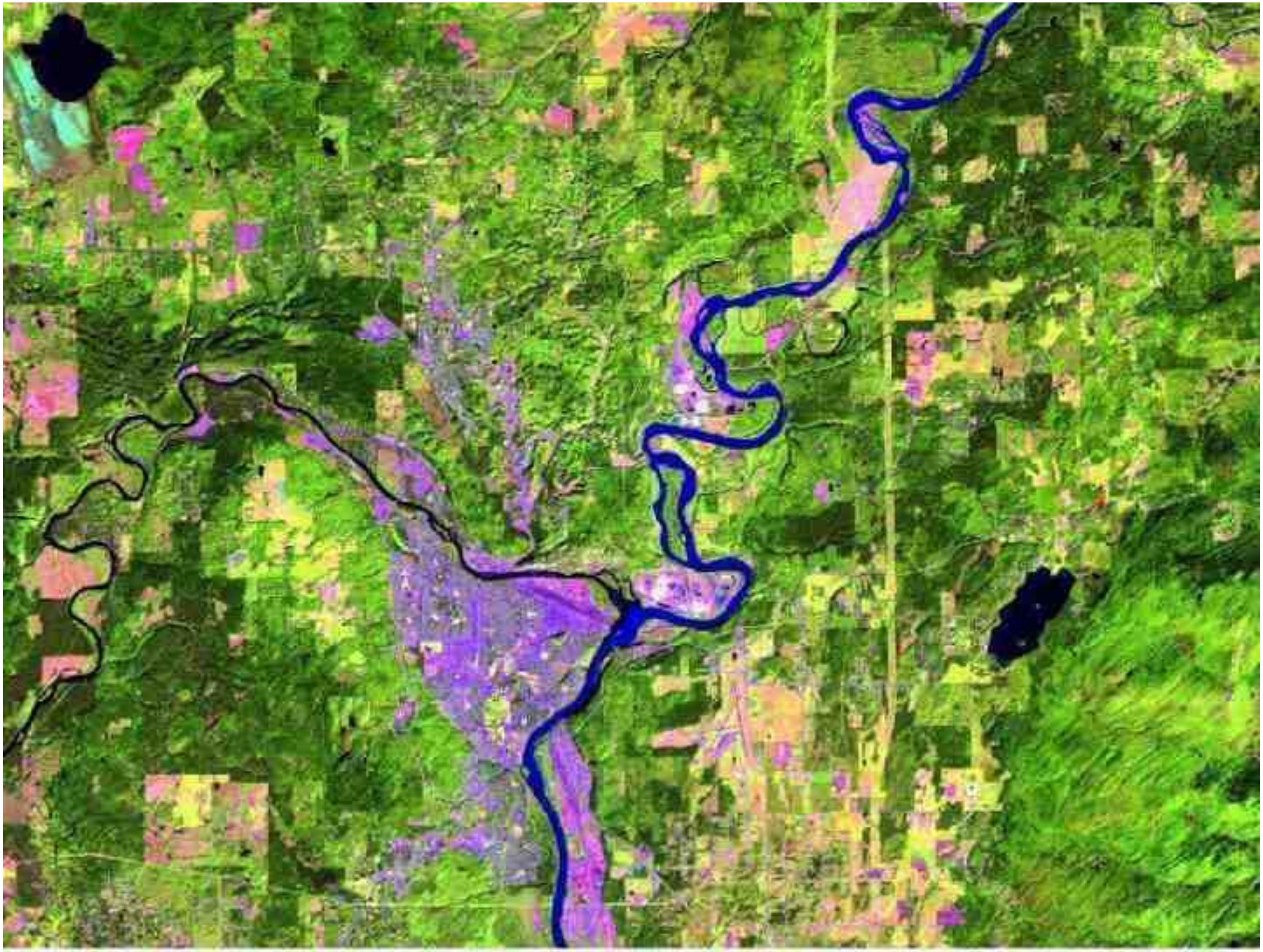
Seasonal: fields, river

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

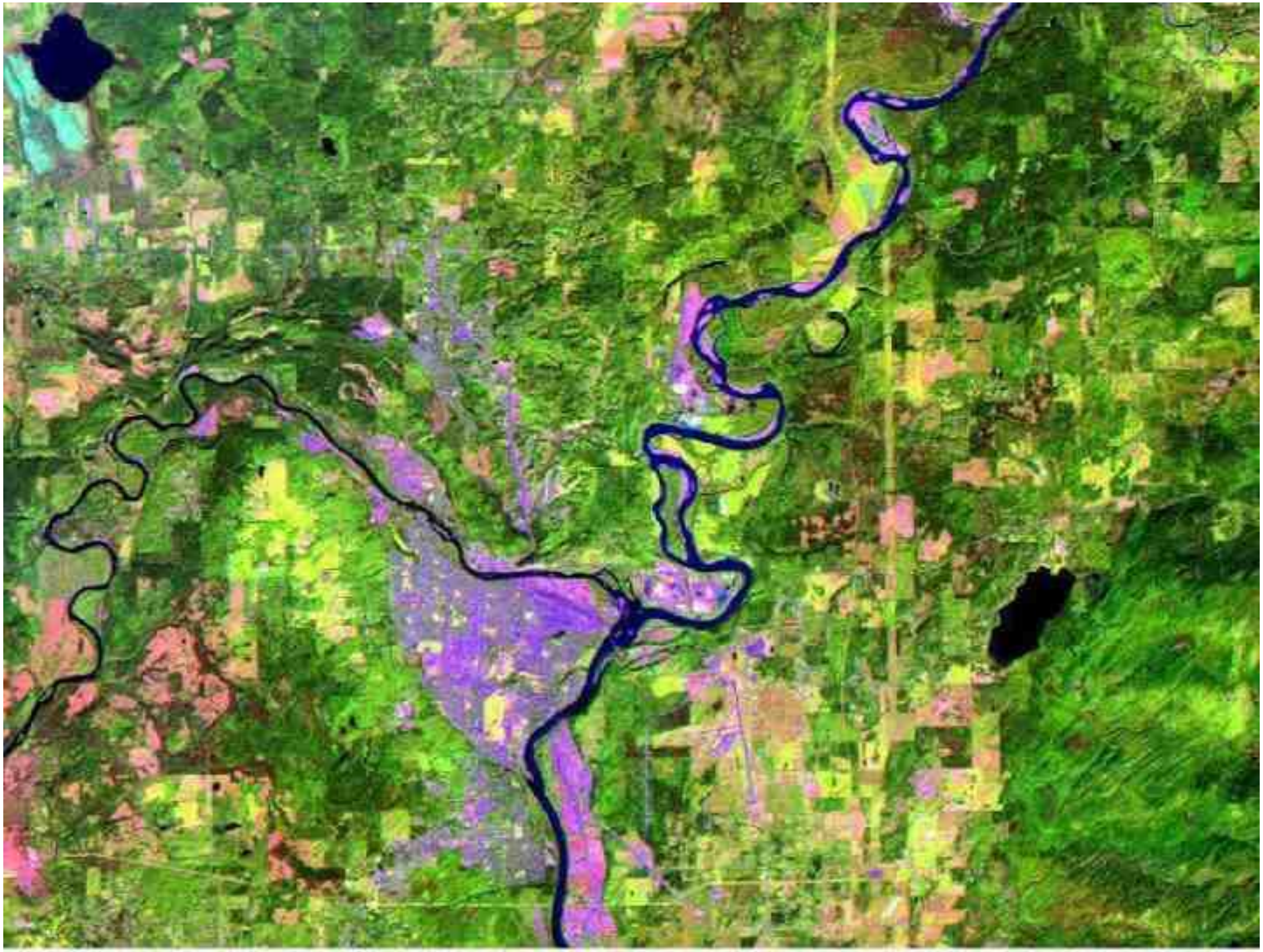


Band 5 (mid-IR), 2011 in red, 1996 in blue/green

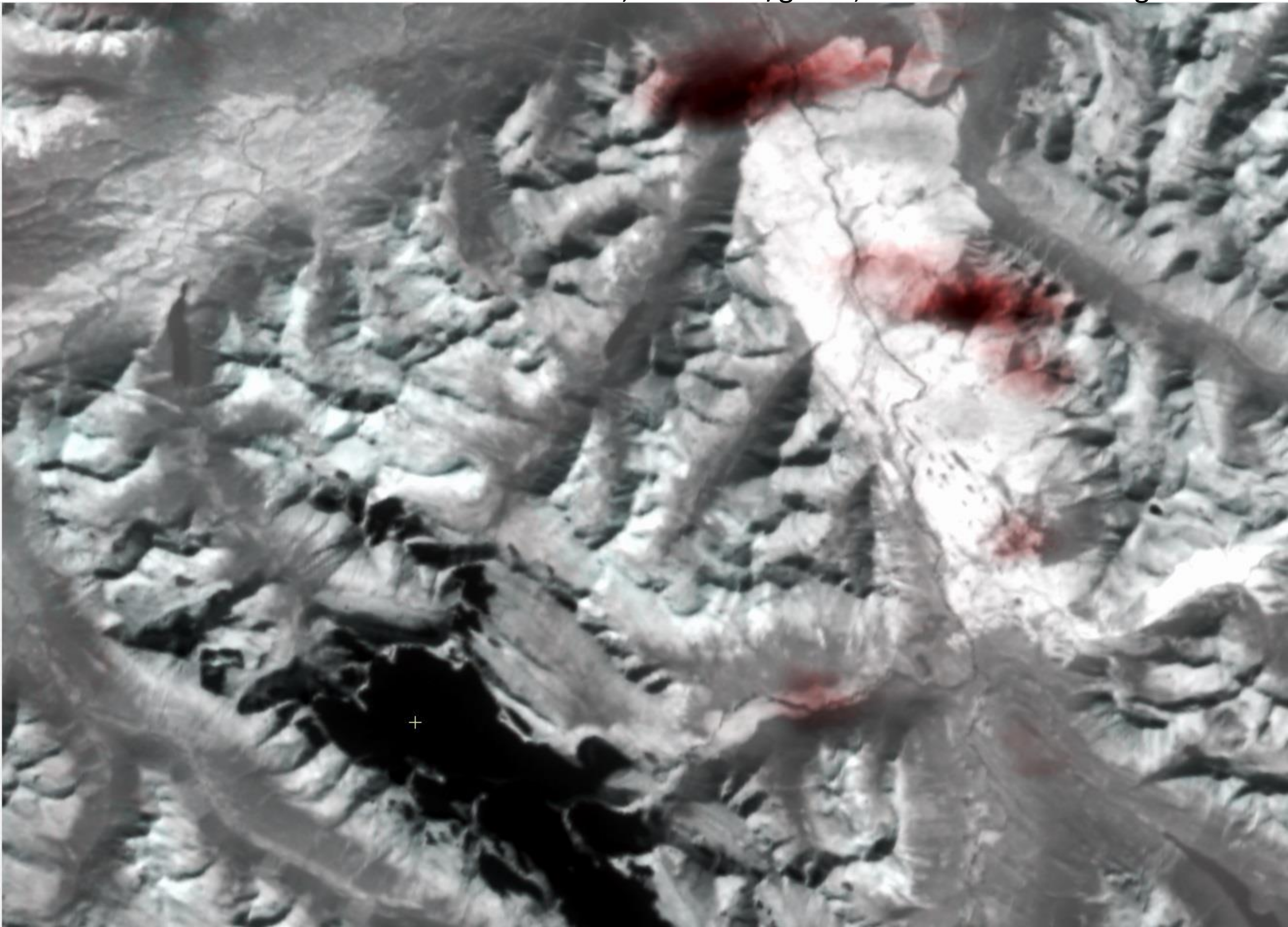
1996



2011

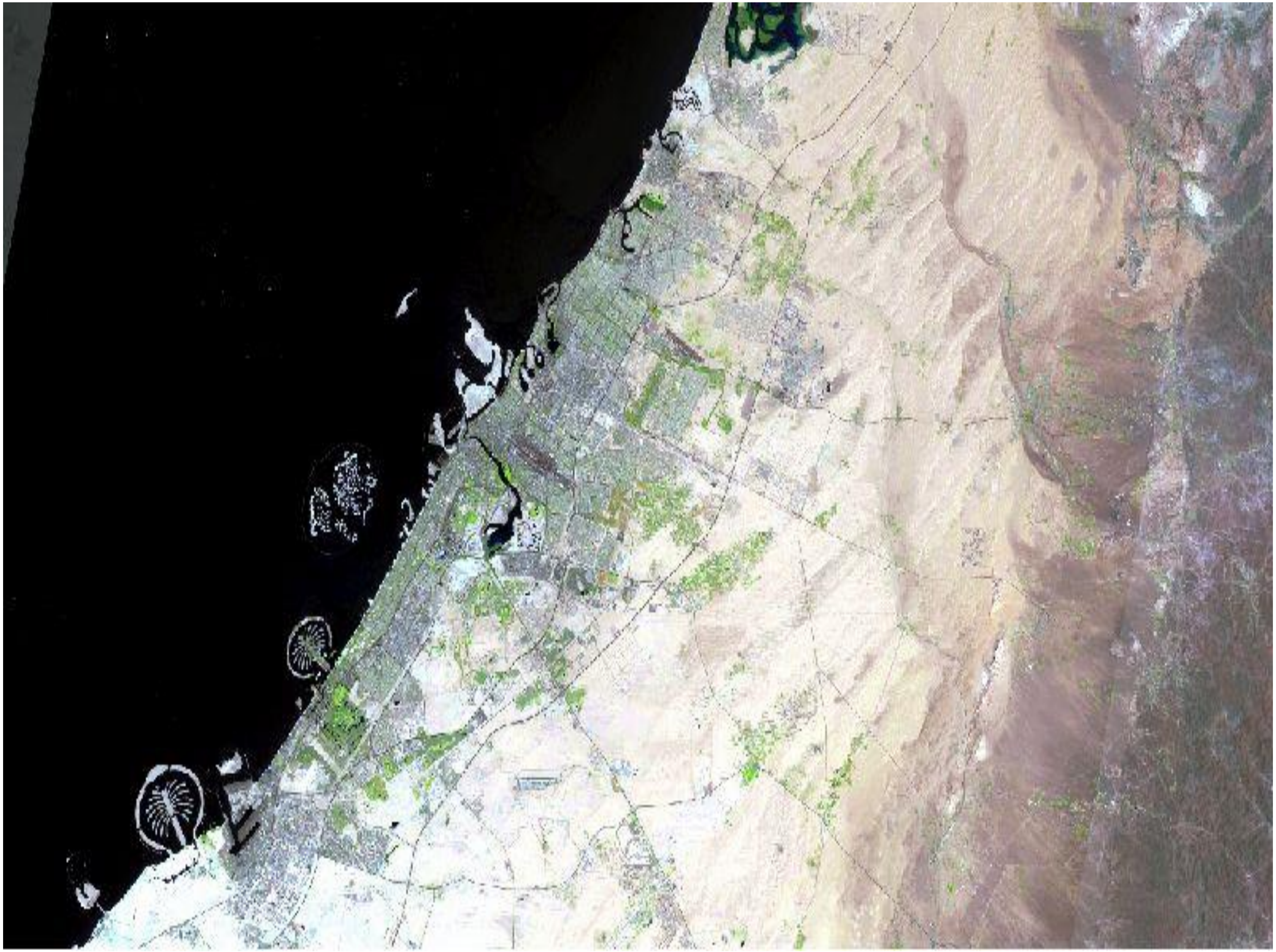


Resthaven – Landsat 8 thermal bands: 10 in red, 11 in blue/green; main difference is high clouds



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 then rebounds

SWIR: 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)

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

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

    …. or also ratio date A/B

- But which band(s) to choose ?
- Bands need to have similar mean / std.dev to compare
- *What happens to **<u>Digital Numbers</u>** if sun angle is lower ??*

Answer: ?

- 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

Example – geog357 (Tasmania): 2006

New plantations mapped by subtracting NDVI 1992-1999

UNBC Geog357 project:

1992-1997 forest clearance

Fig.1. Colour composite using bands 3,4 and 5 from 1992

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

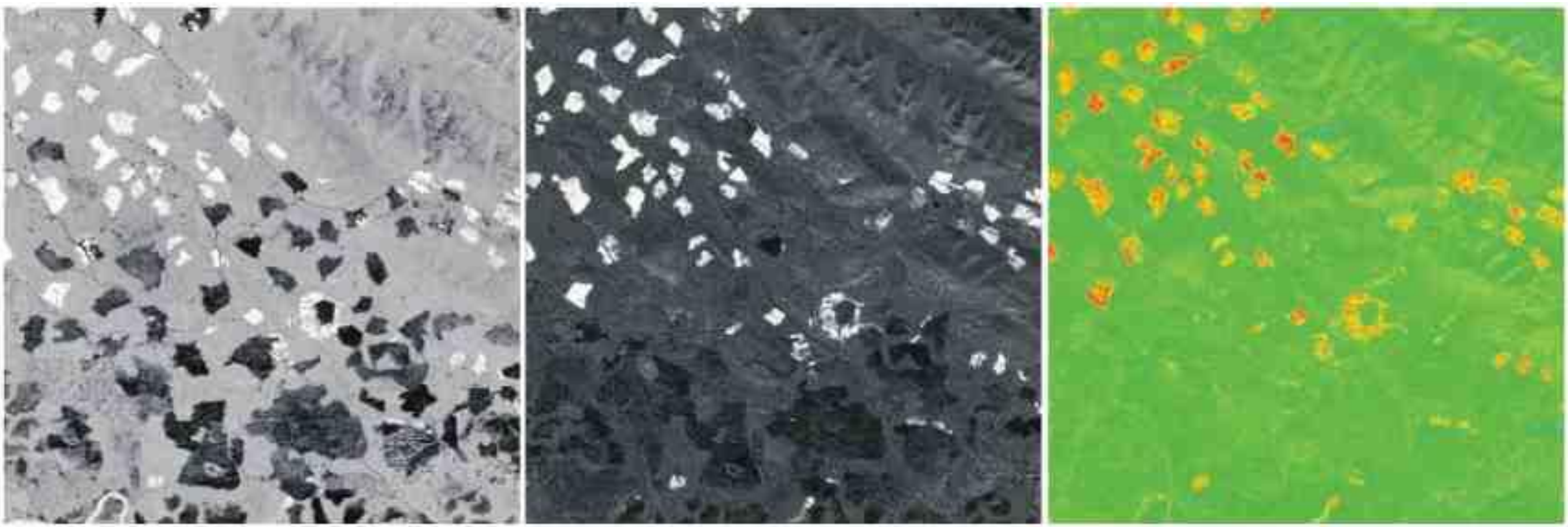
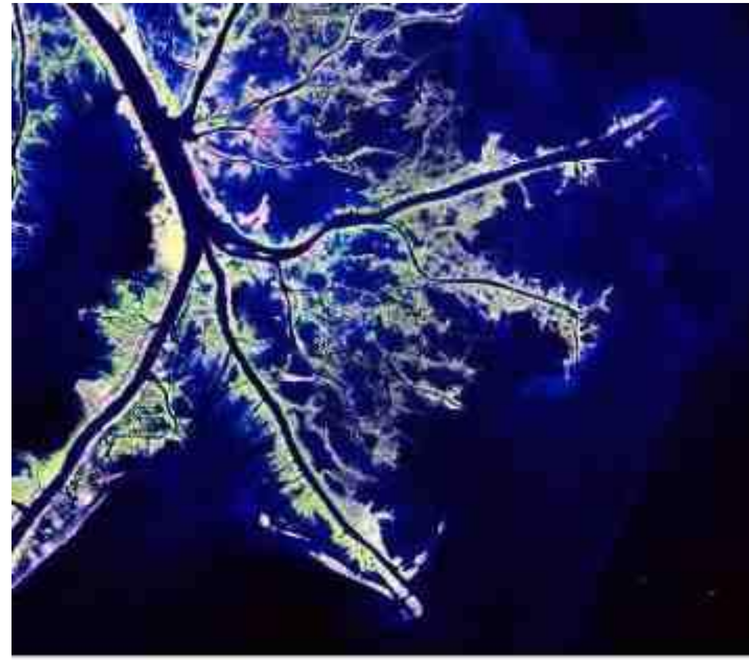


Fig. 3, 4 and 5. Tasseled Cap Wetness subtraction, PC2 and a pseudocolour display of the NDWI image subtraction respectively. Deforested areas are white in figures 3 and 4 and red in figure 5. Black areas were harvested prior to 1992.

1992-97 cutblock size has decreased

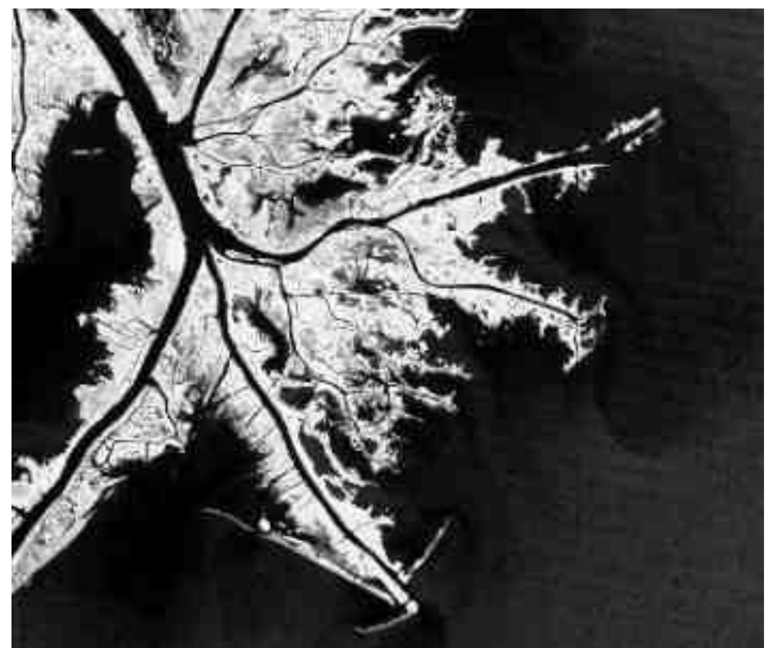
Mississippi Delta: TM543: 2004, 2005, 2010 (before/after Hurricane Katrina, Aug 2005)

2004



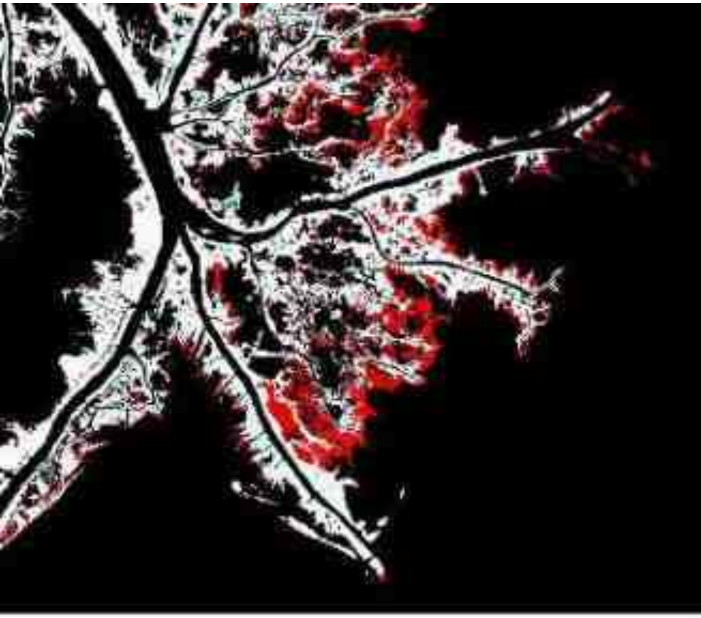
2005

2010

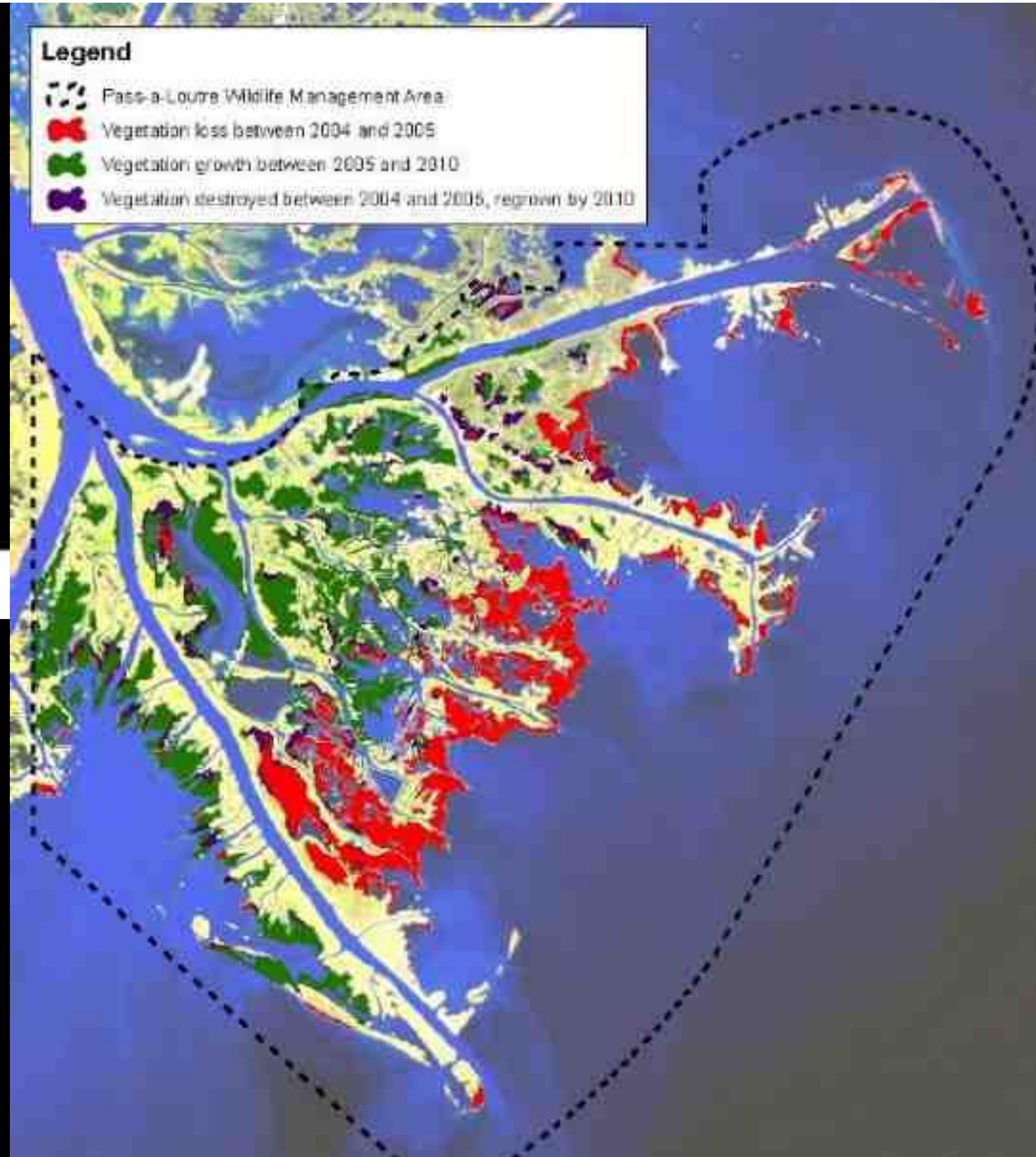


NDVI 2010

NDVI difference 2004-5

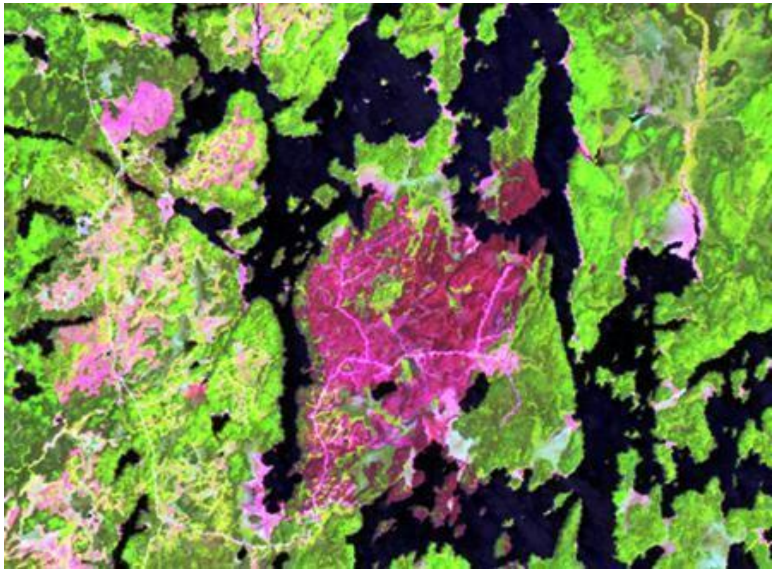


NDVI difference 2005-10

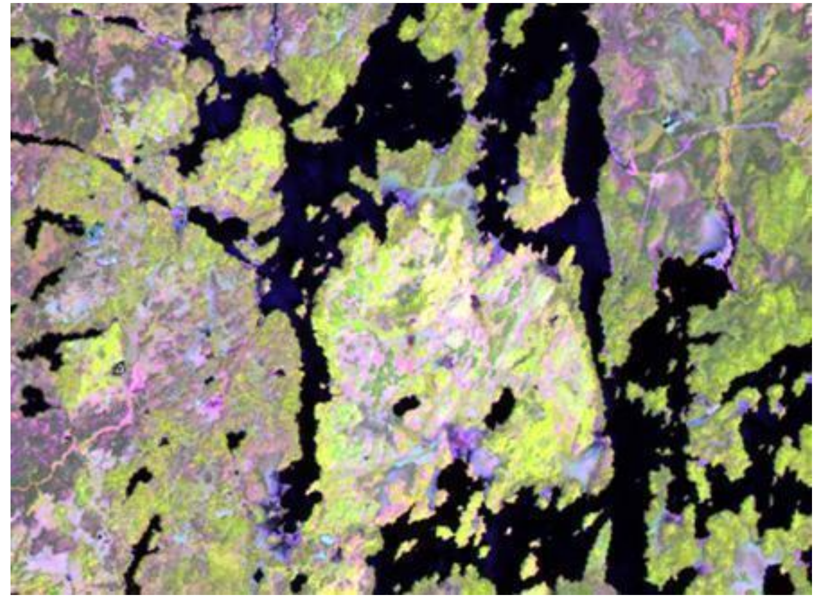


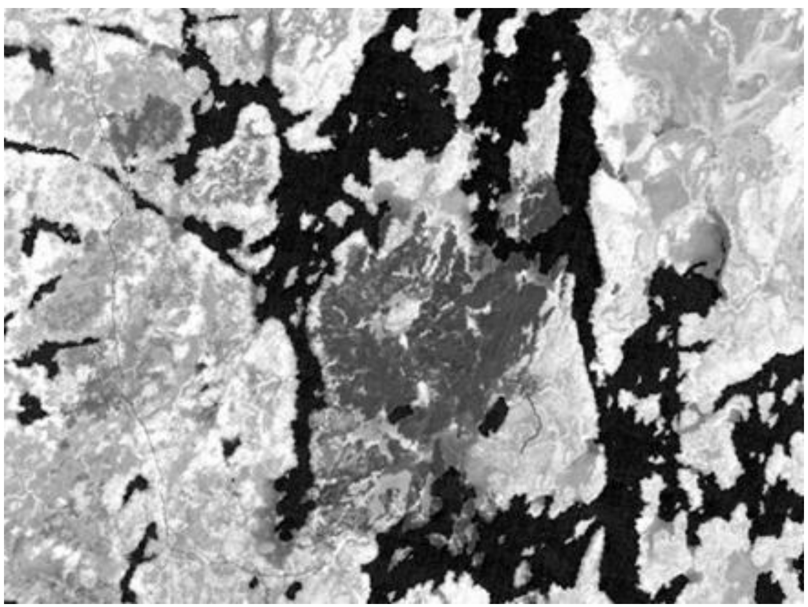
The use of NDVI to determine vegetative green-up after a forest fire Geog357

1987

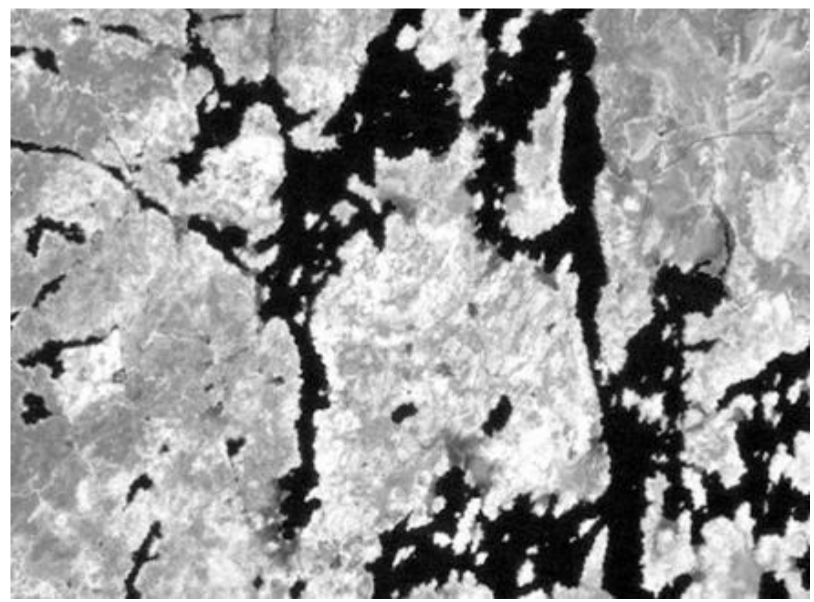


2002



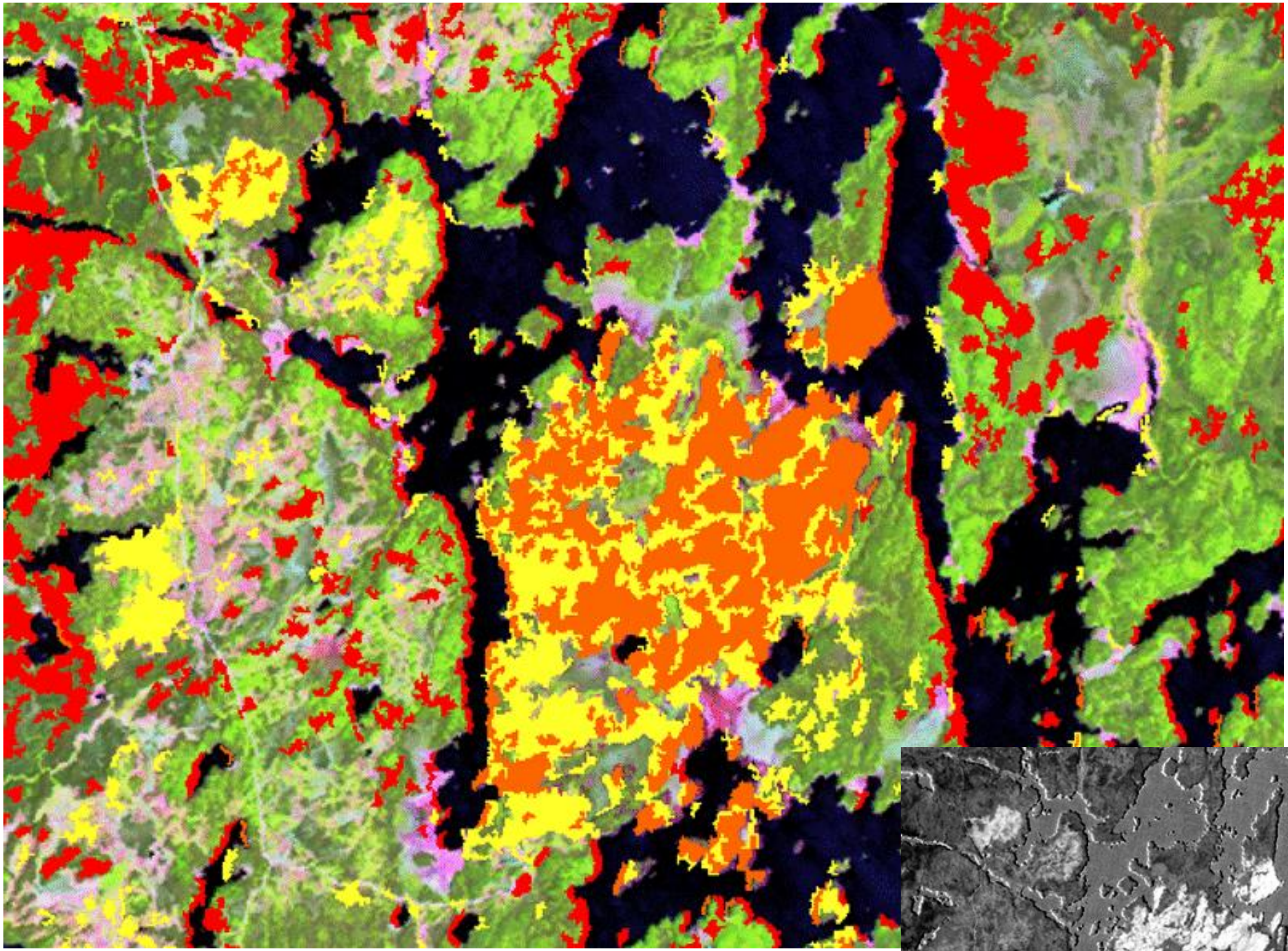


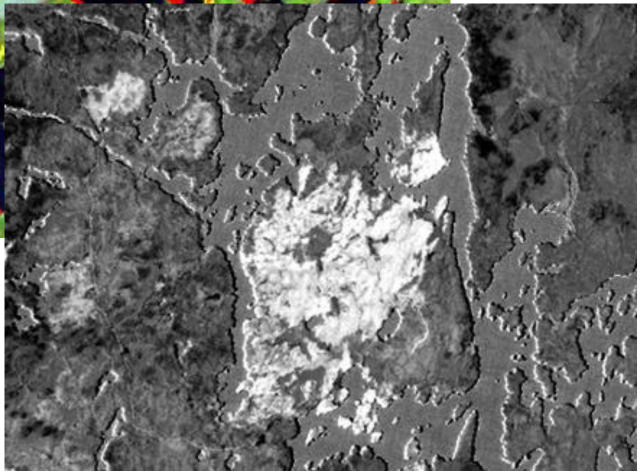
NDVI



NDVI

The use of NDVI to determine vegetative green-up after a forest fire



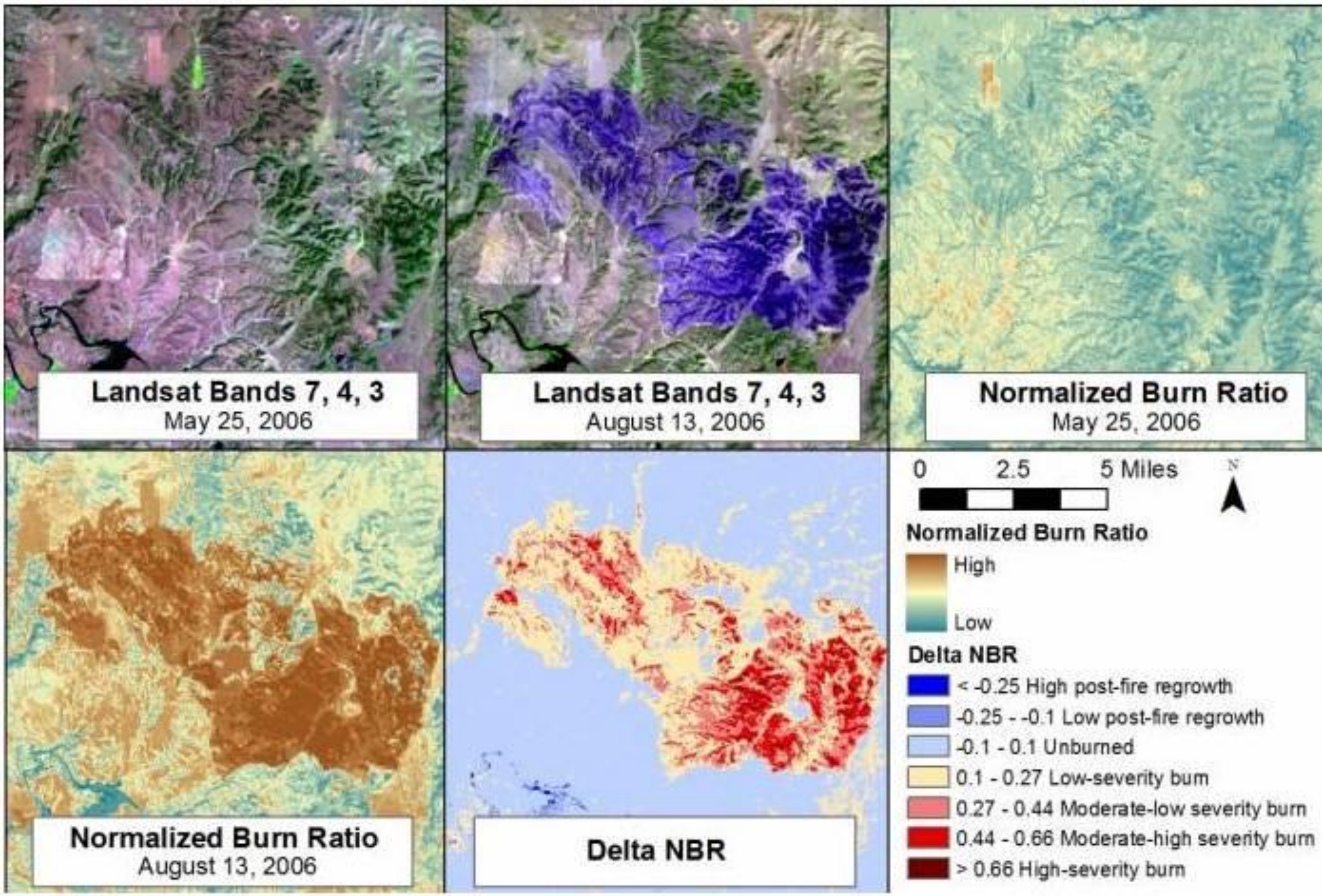


NDVI difference – 1987-2002

Red - Negative Growth Range **Clear -** Neutral Growth Range
Yellow - Minimal Positive Growth **Orange** - Maximum Positive Growth

Normalised Burn Ratio (Index)

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



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)

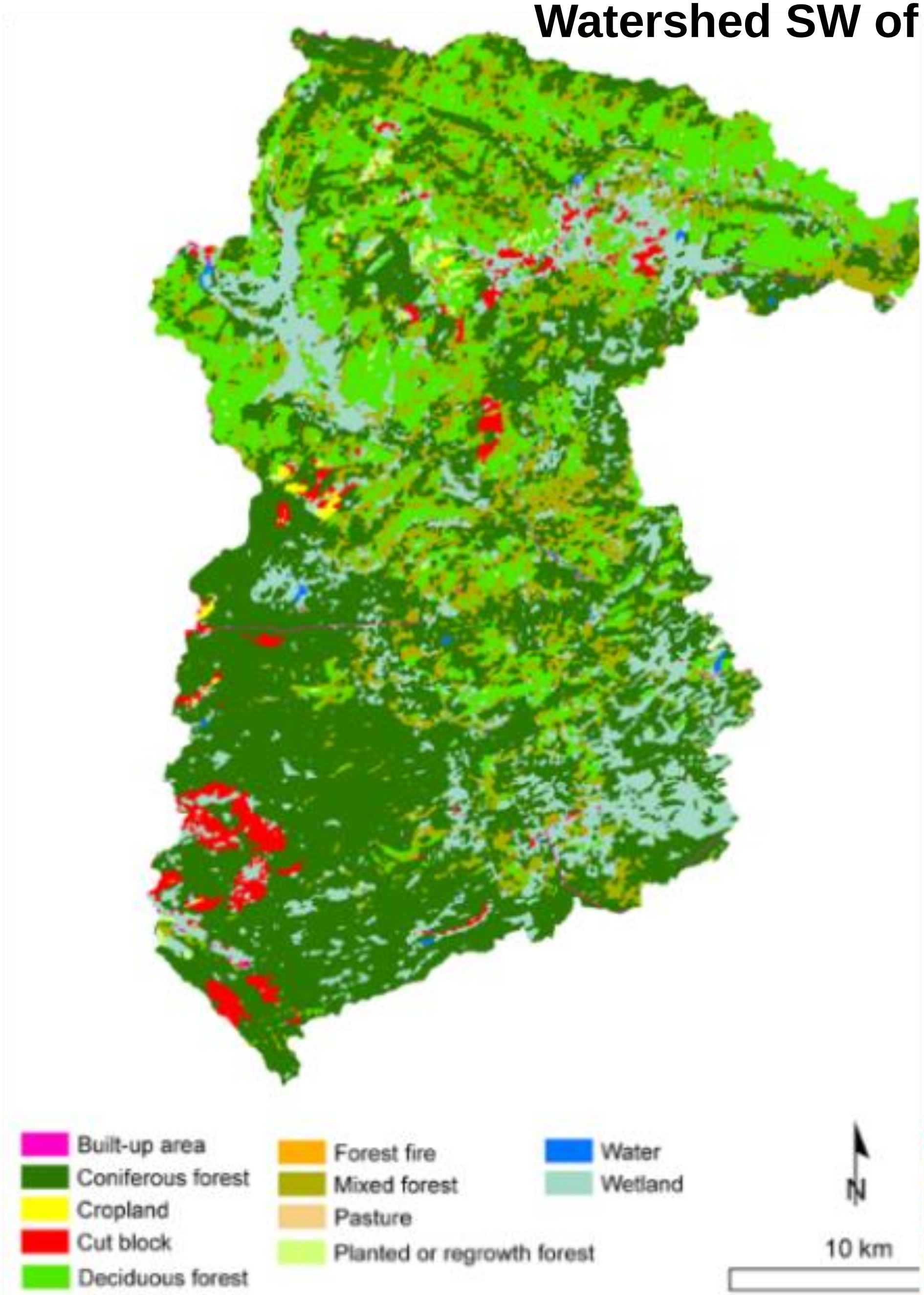
	Water	Cropland	Rangeland	Forest	Total
Water	2842	3	4	0	2849
Cropland	1	31874	596	0	32471
Rangeland	2	1063	72487	23	73575
Forest	0	8742	328	53221	62291
Total	2845	41682	73415	53244	171186

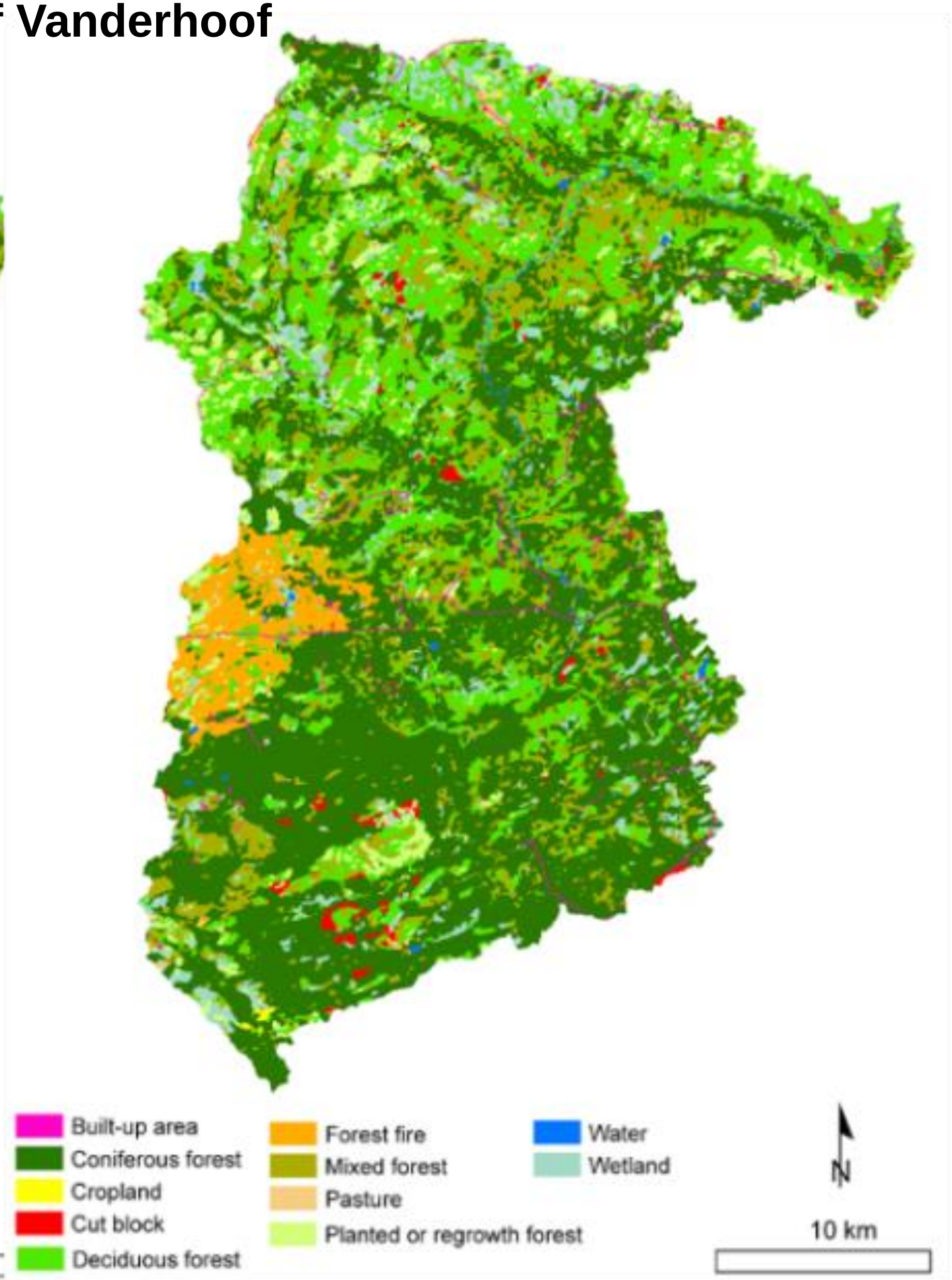
The matrix multiplies as number of classes increase

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

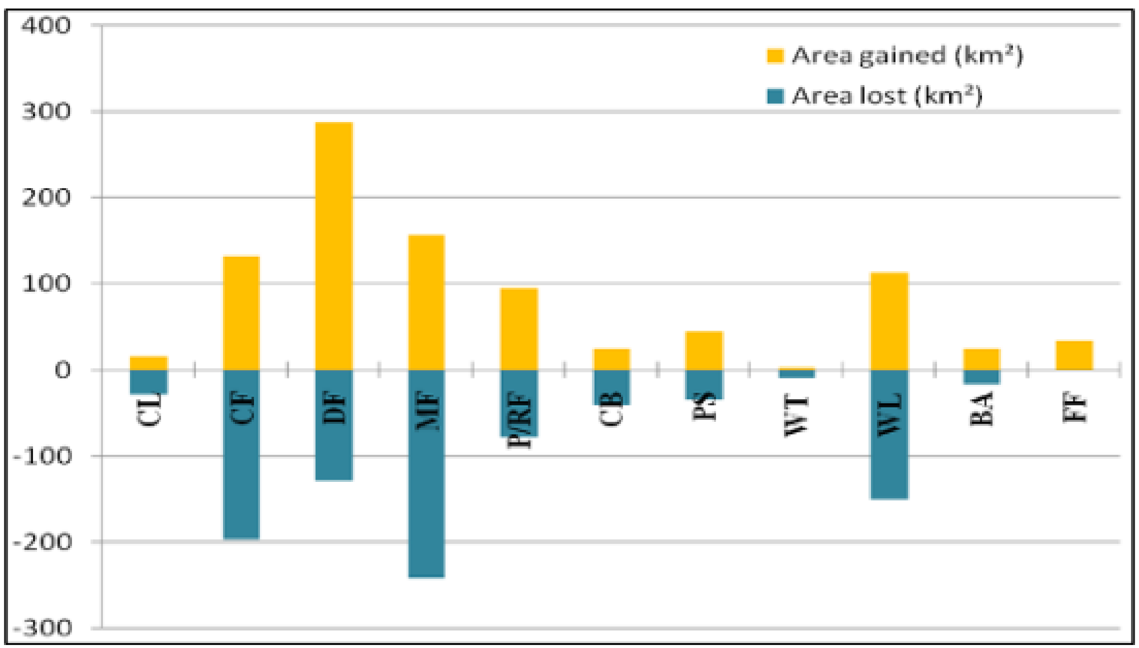
Recent UNBC M.Sc thesis – supervised classifications 1984 and 2010

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



Growth of Toronto Metro Area 1974-2014

Classification of Landsat images