Forest disturbance and recovery from time series Landsat data: What are we talking about?

Michael A. Wulder

Joanne C. White, Txomin Hermosilla, Nicholas C. Coops, Geordie Hobart

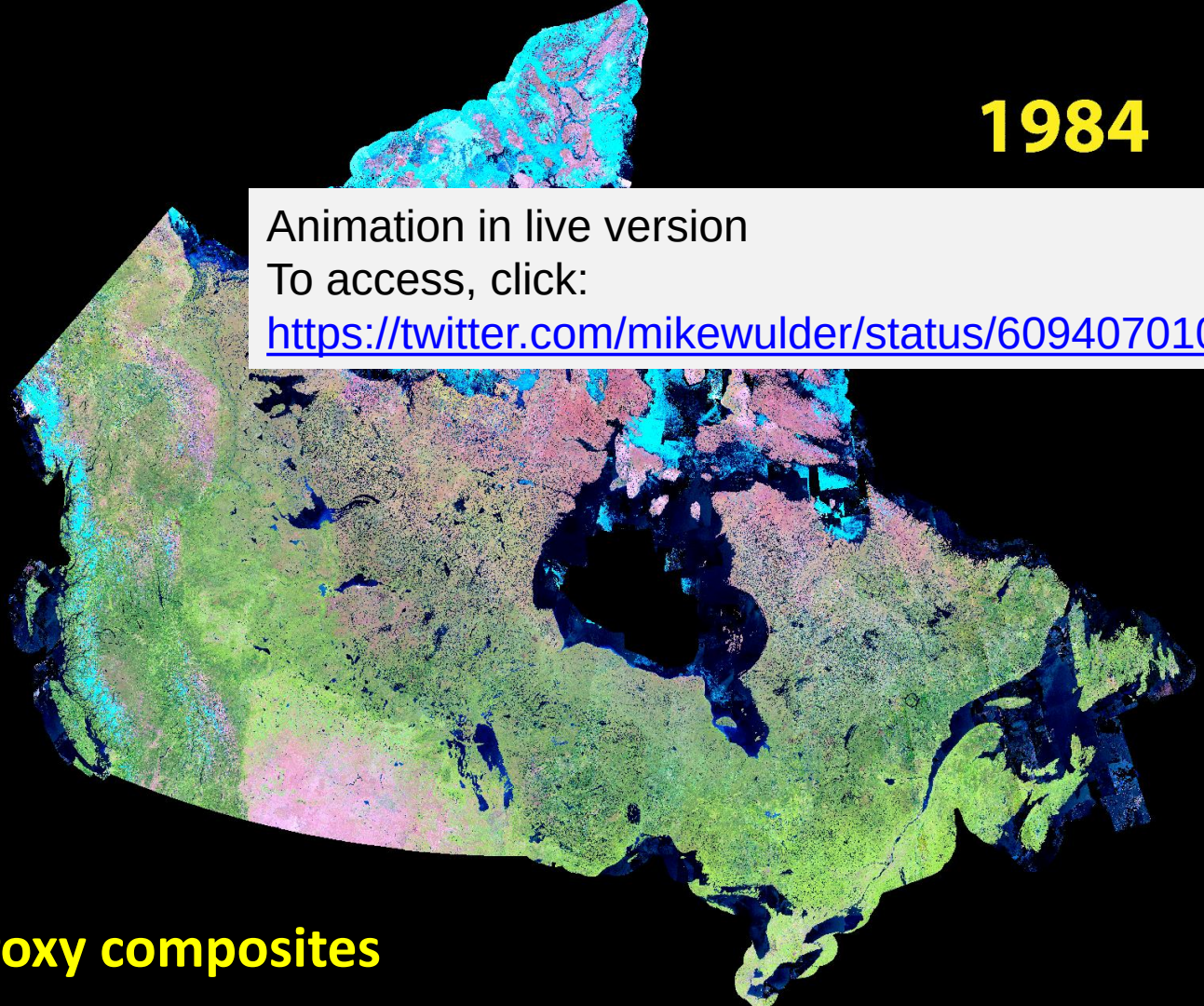
THE UNIVERSITY OF BRITISH COLUMBIA

Natural Resources Canada

Ressources naturelles Canada

…and what the talk is about:

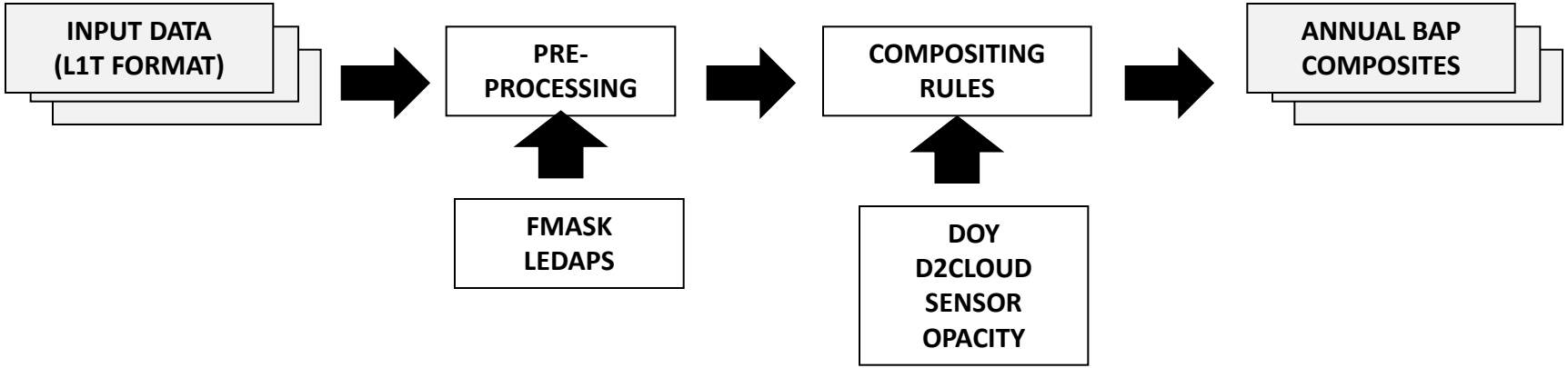
- Status report on reconstructing the history of Canada's forests using Landsat
- Implications:
  - Change:
    - Disturbance (nature of change?)
    - Recovery / regeneration (what comes back?)
  - Attributes:
    - Land cover, structure (ht, vol, …), species



Animation in live version
To access, click:
https://twitter.com/mikewulder/status/609407010552029184

Annual proxy composites

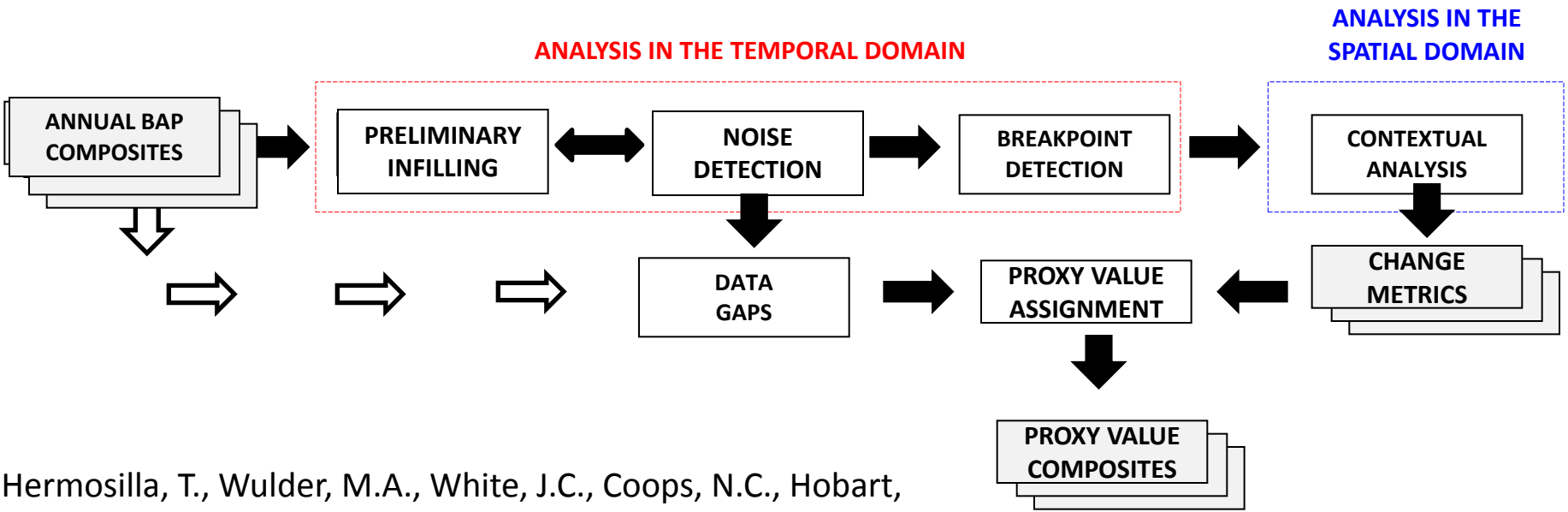
Compositing approach: Annual BAP



UPDATE: Target DOY = ± 30 days; Sensor = increased penalty for ETM+ SLC-off

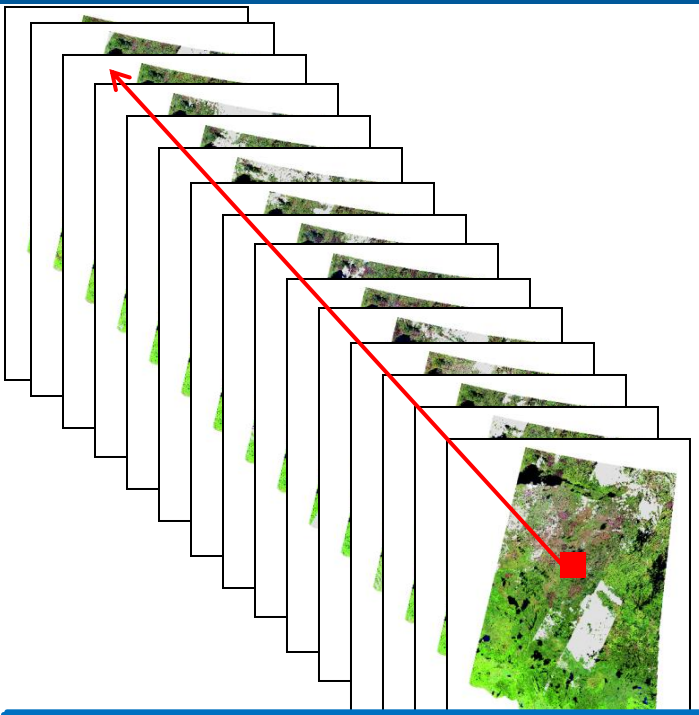
White, J.C., Wulder, M.A., Hobart, G.W., Luther, J.E., Hermosilla, T., Griffiths, P., Coops, N.C., Hall, R.J., Hostert, P., Dyk, A., Guindon, L. 2014. Pixel-based image compositing for large-area dense time series applications and science. *Canadian Journal of Remote Sensing*, 40(3): 192-212. LINK

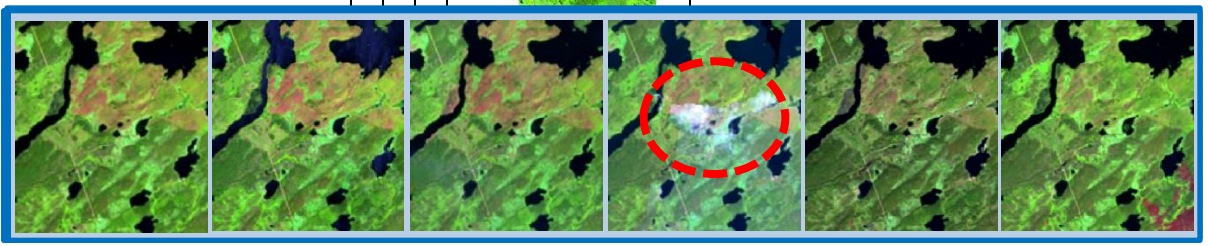
Compositing approach: Proxy BAP



Hermosilla, T., Wulder, M.A., White, J.C., Coops, N.C., Hobart, G.W. 2015. An integrated Landsat time series protocol for change detection and generation of annual gap-free surface reflectance composites. Remote Sensing of Environment. Vol. 158, pp. 220–234. LINK

Methods | Pixel-series analysis





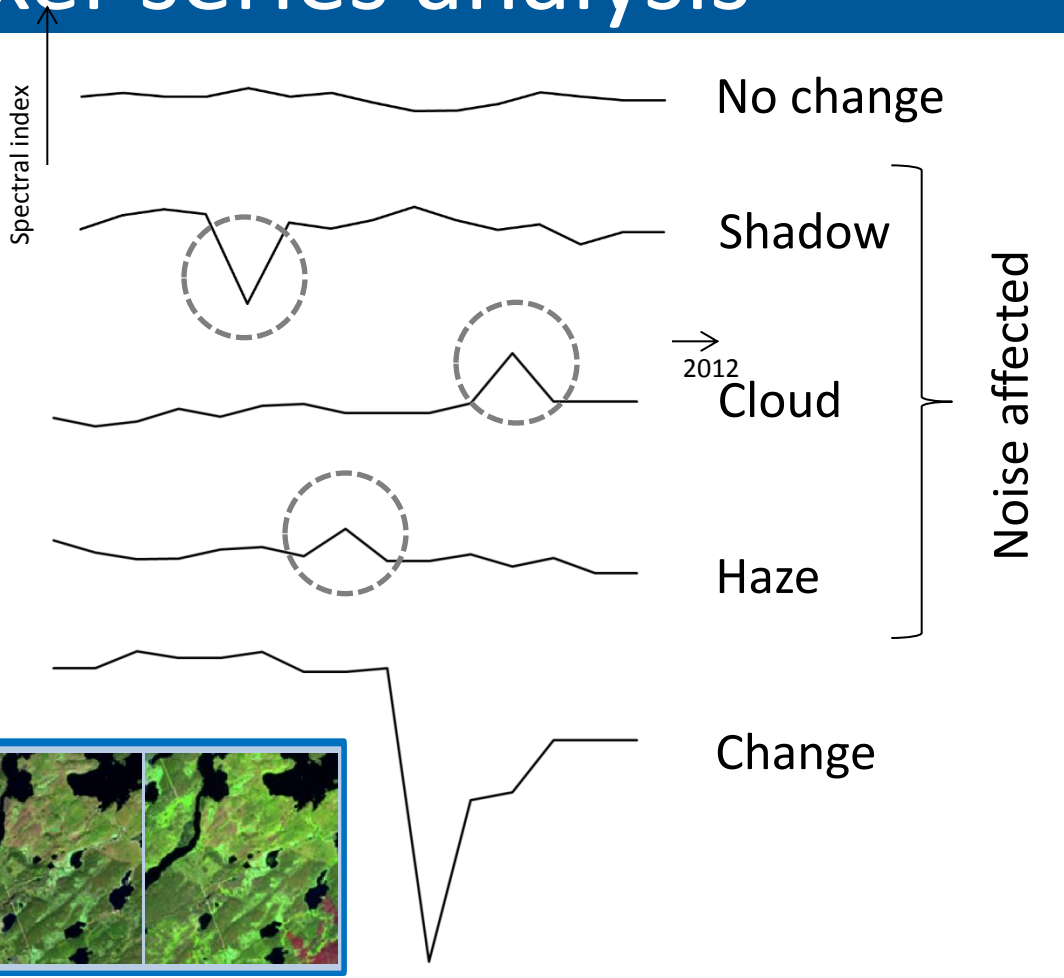
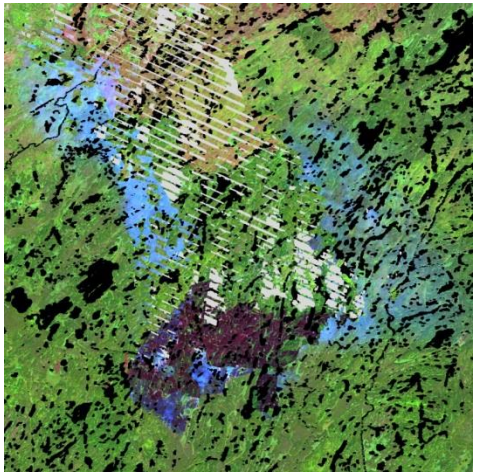
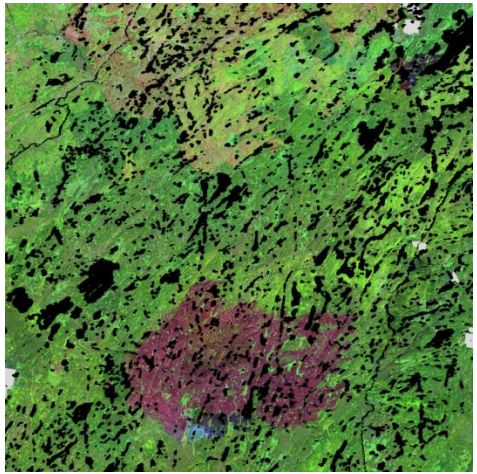


Image compositing process

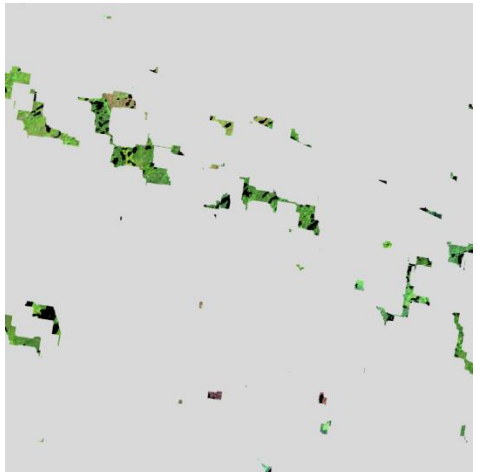
1. Annual BAP composites



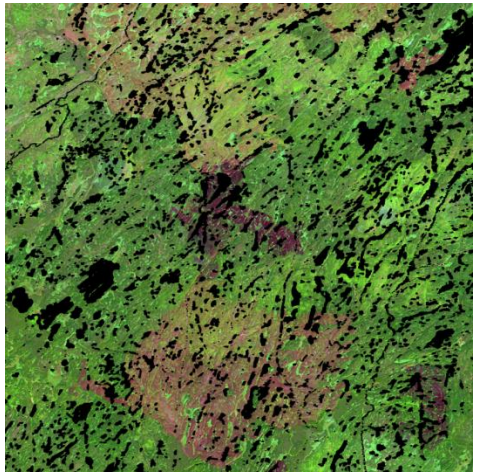
2004



2005



2006

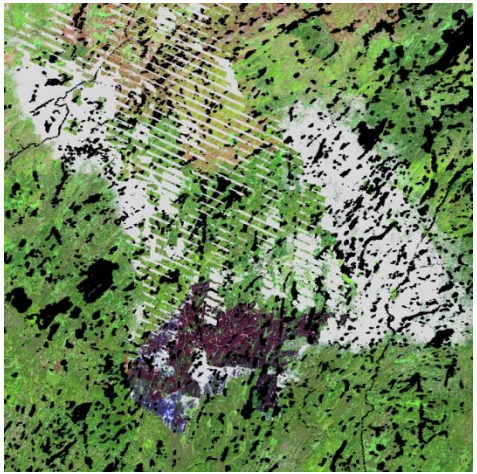


2007

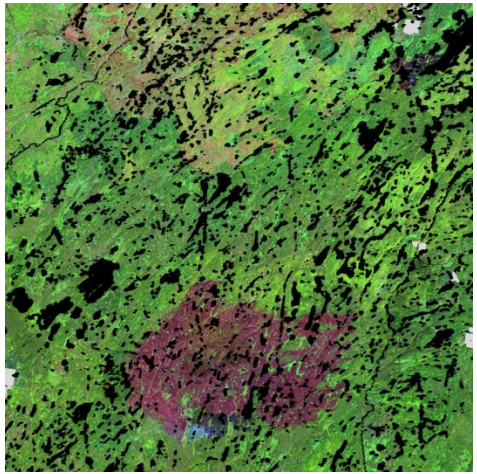
Data gap

Image compositing process

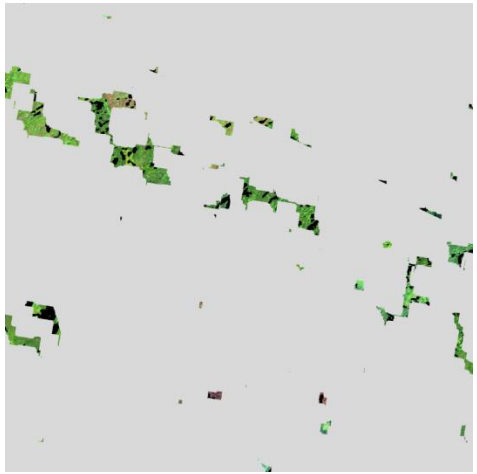
2. Noise detection



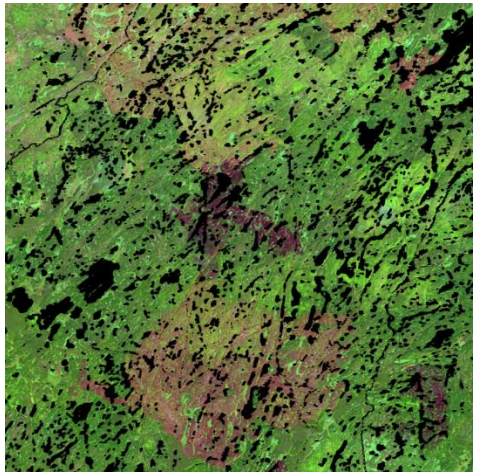
2004



2005



2006

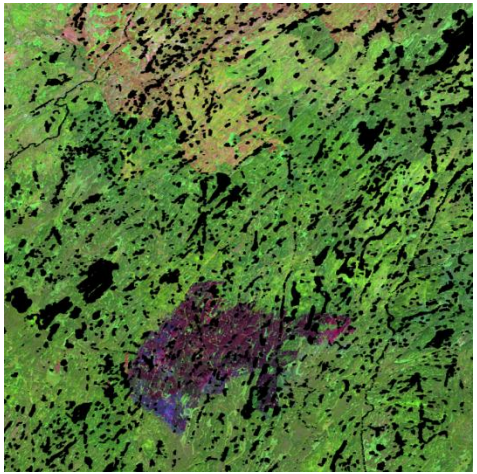


2007

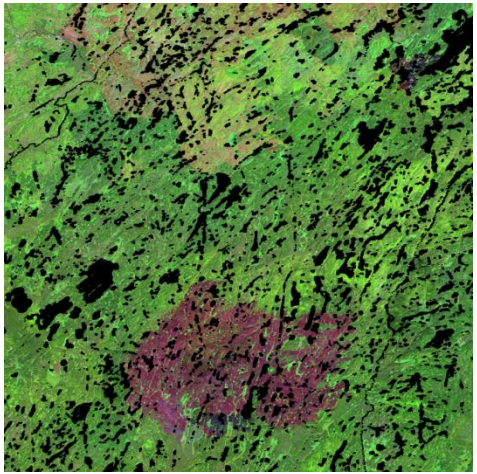
Data gap

Image compositing process

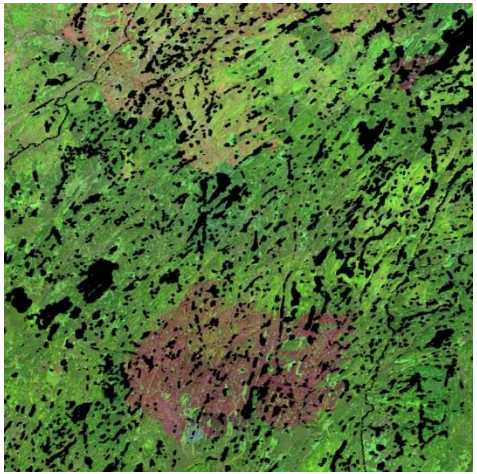
3. Annual proxy composites



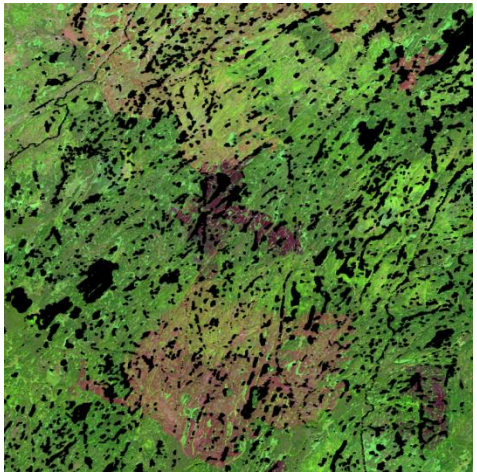
2004



2005



2006



2007

Data gap

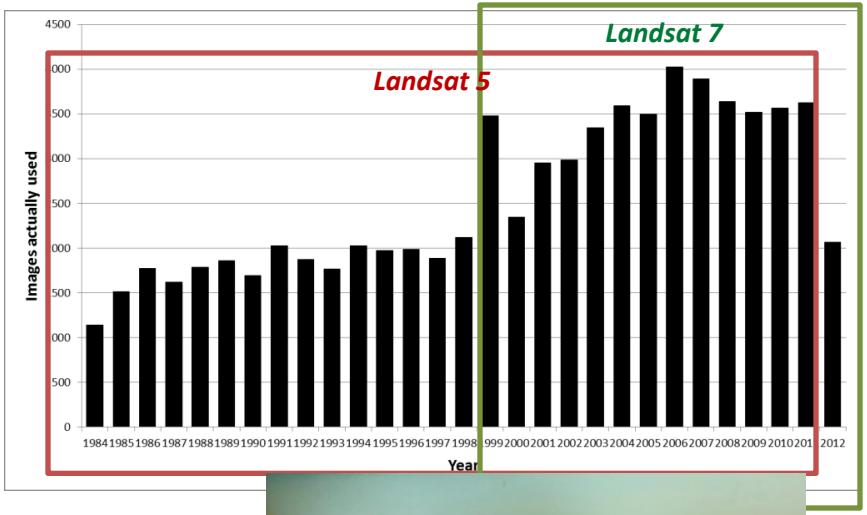
Imagery and products

INPUT DATA

- Images downloaded **>100,000**

- Surface reflectance bands
- Clouds/shadow screening
- Metrics for scoring
- Water masks
- Data masks

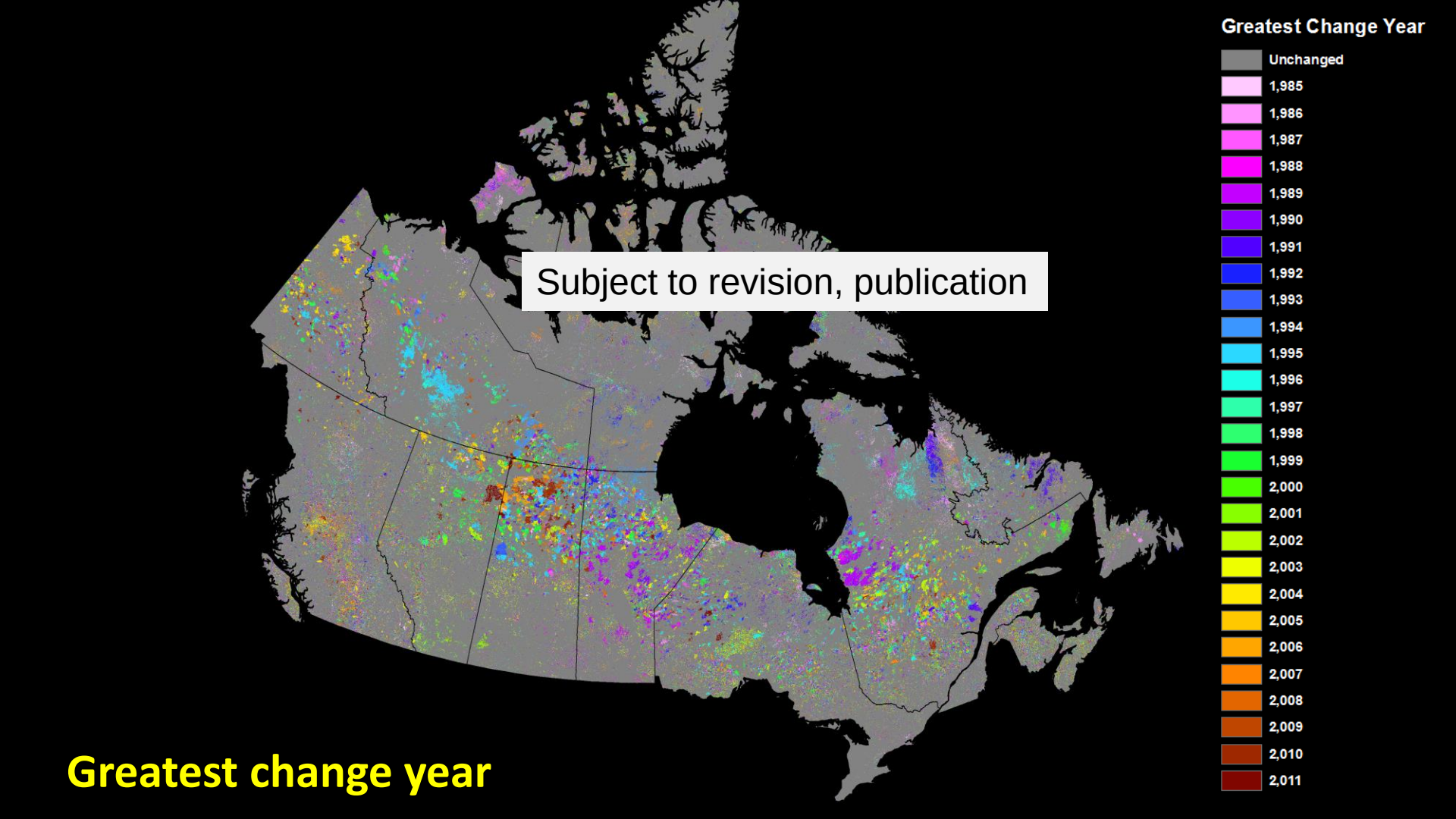
>400 TB



PRODUCTS (so far)

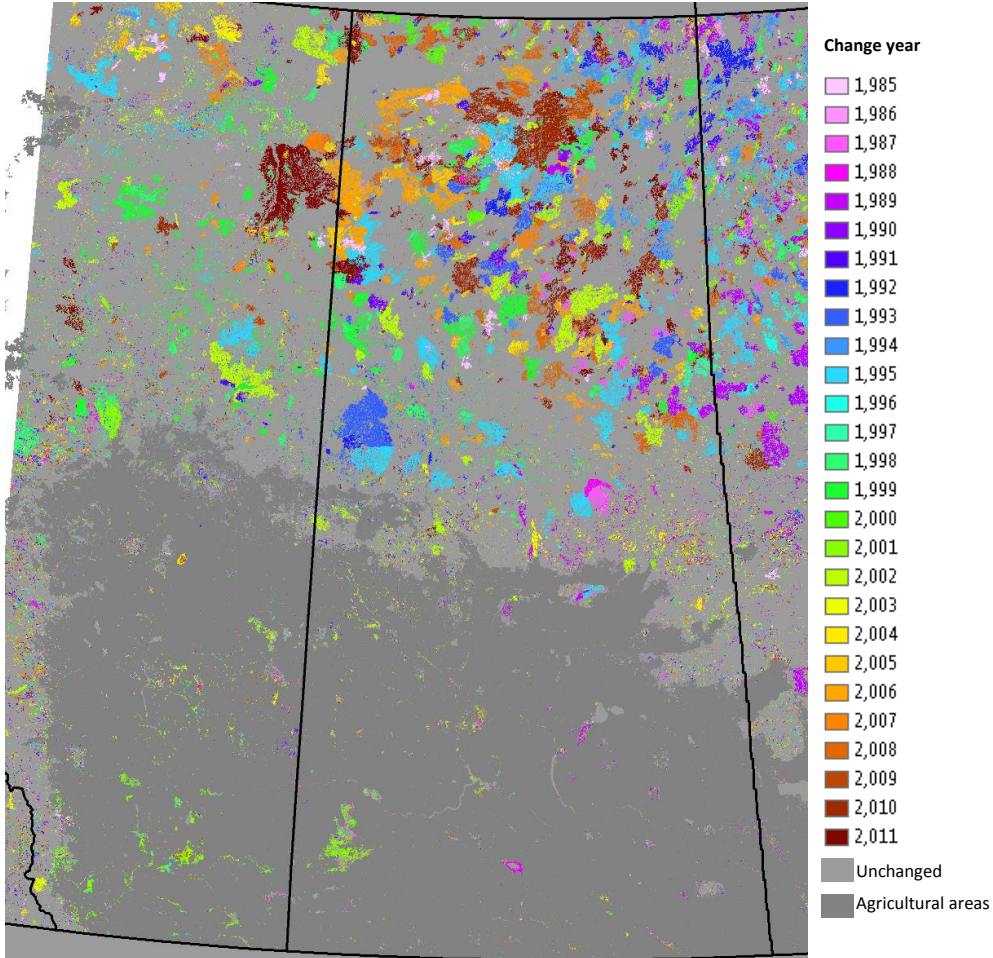
- Proxy composites (all years) **~ 20 TB**
- Changes & change metrics

White & Wulder 2014. The Landsat observation record of Canada: 1972–2012. Canadian Journal of Remote Sensing. 39(4): 455-467. LINK.

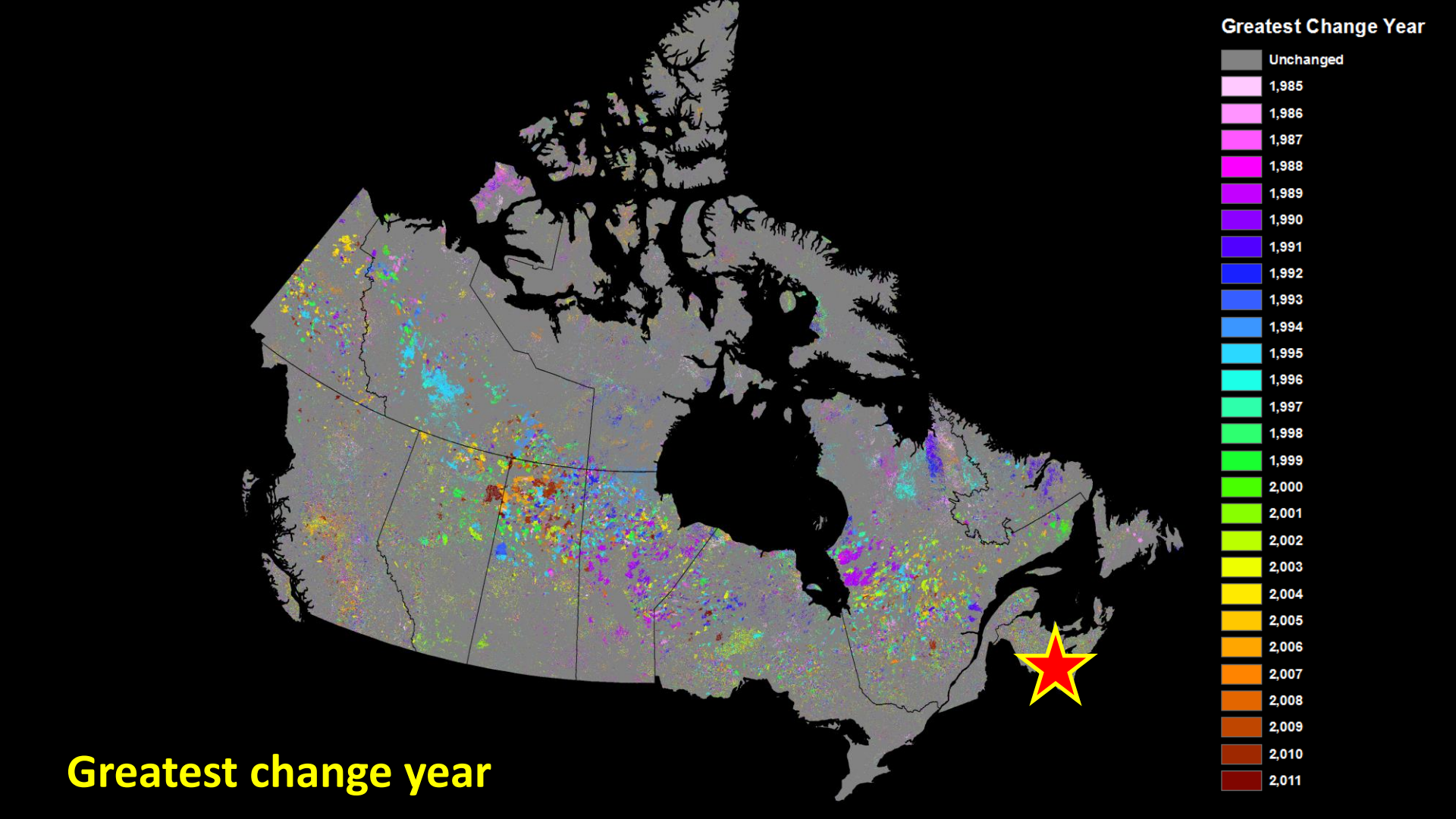


Greatest change year

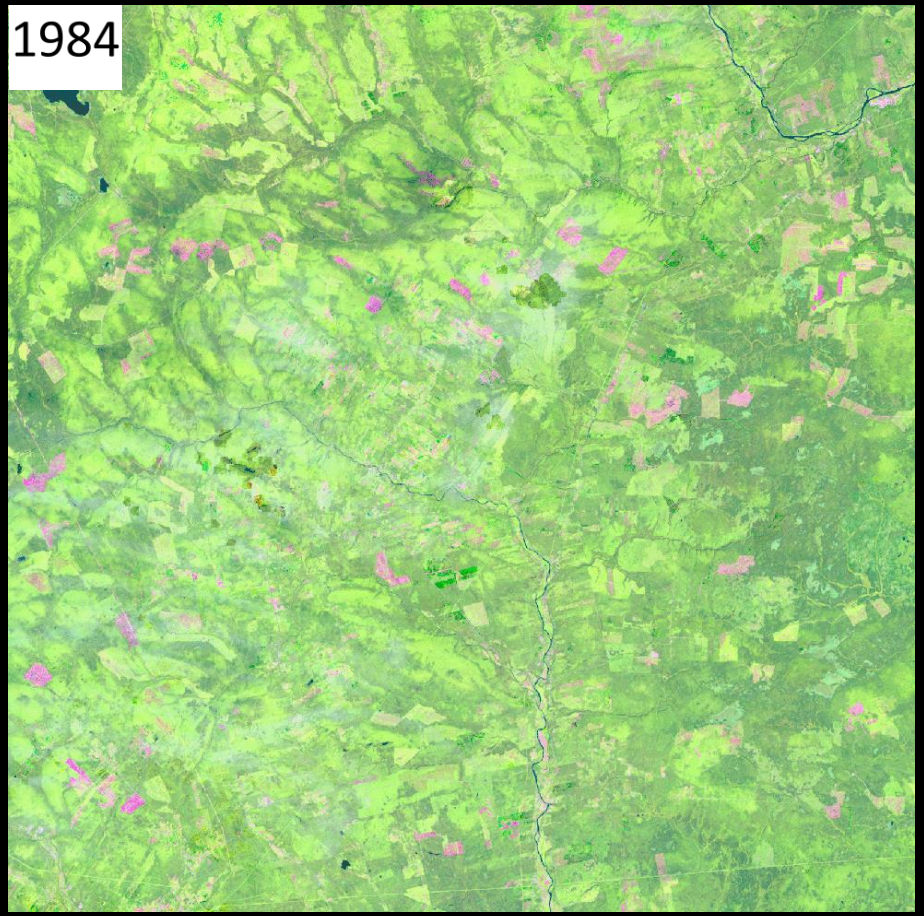
Change detection outputs

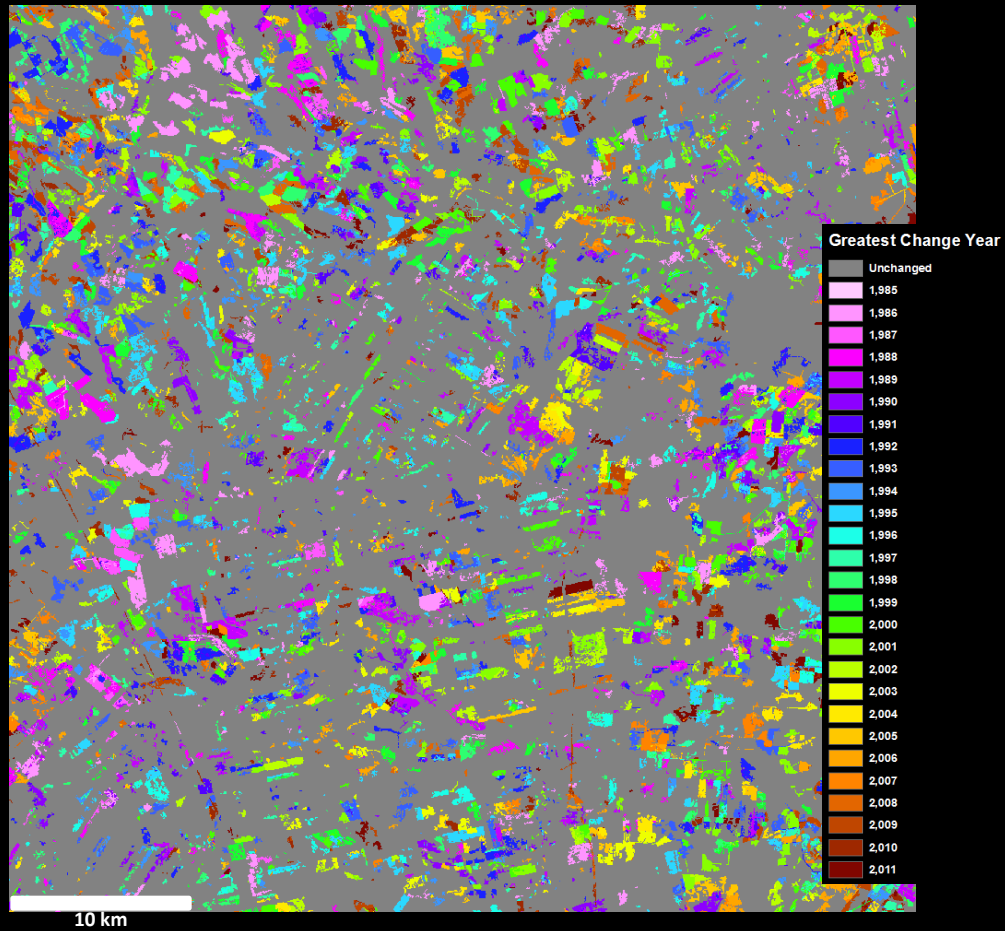


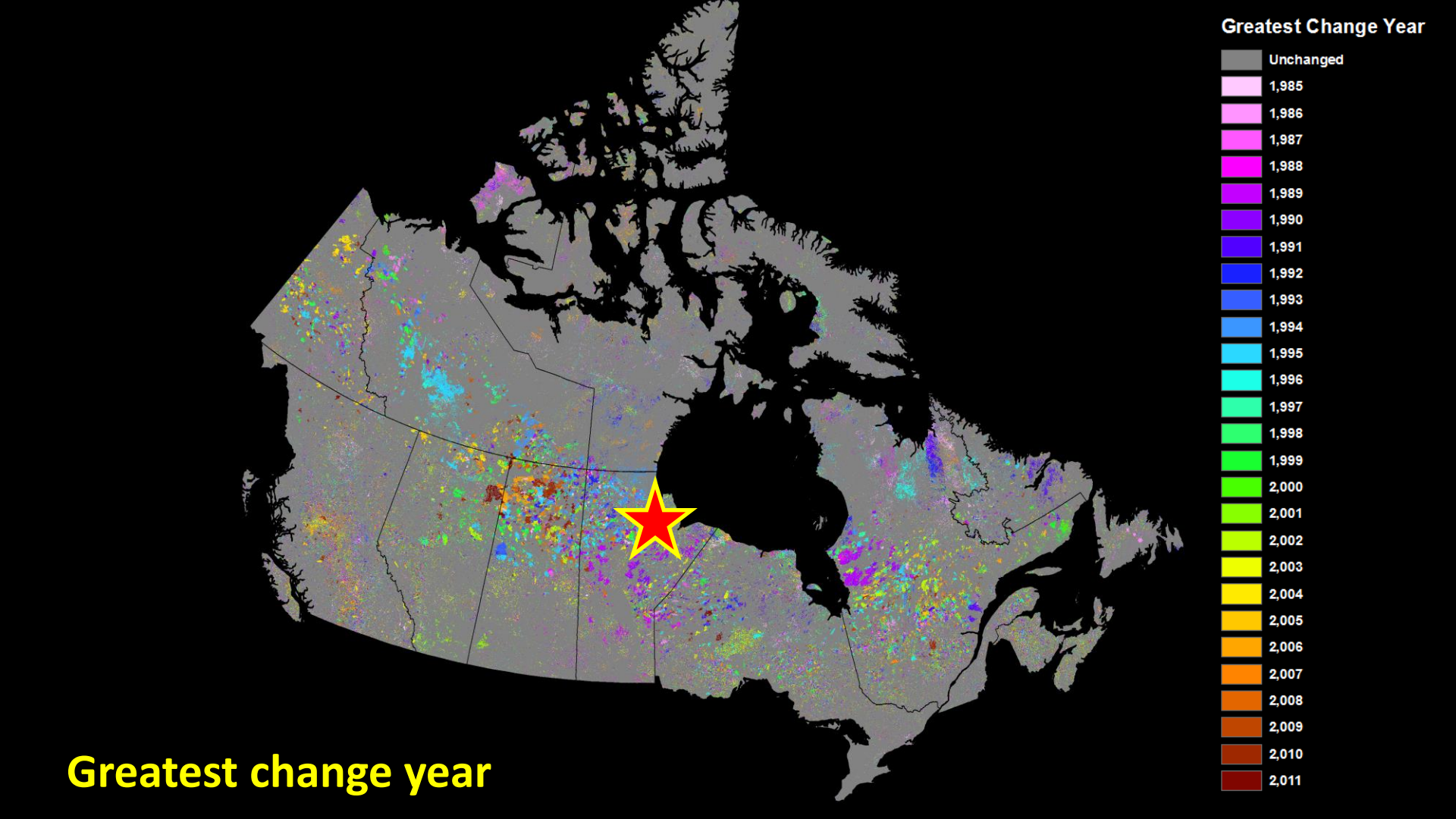
	Metric
Pre-change	Pre-change magnitude variation
	Pre-change persistence
	Pre-change evolution rate
Change	Change year
	Change persistence
	Change magnitude variation
	Change rate
Post-change	Post-change magnitude variation
	Post-change persistence
	Post-change evolution rate


Greatest Change Year
Unchanged
1,985
1,986
1,987
1,988
1,989
1,990
1,991
1,992
1,993
1,994
1,995
1,996
1,997
1,998
1,999
2,000
2,001
2,002
2,003
2,004
2,005
2,006
2,007
2,008
2,009
2,010
2,011
Greatest change year

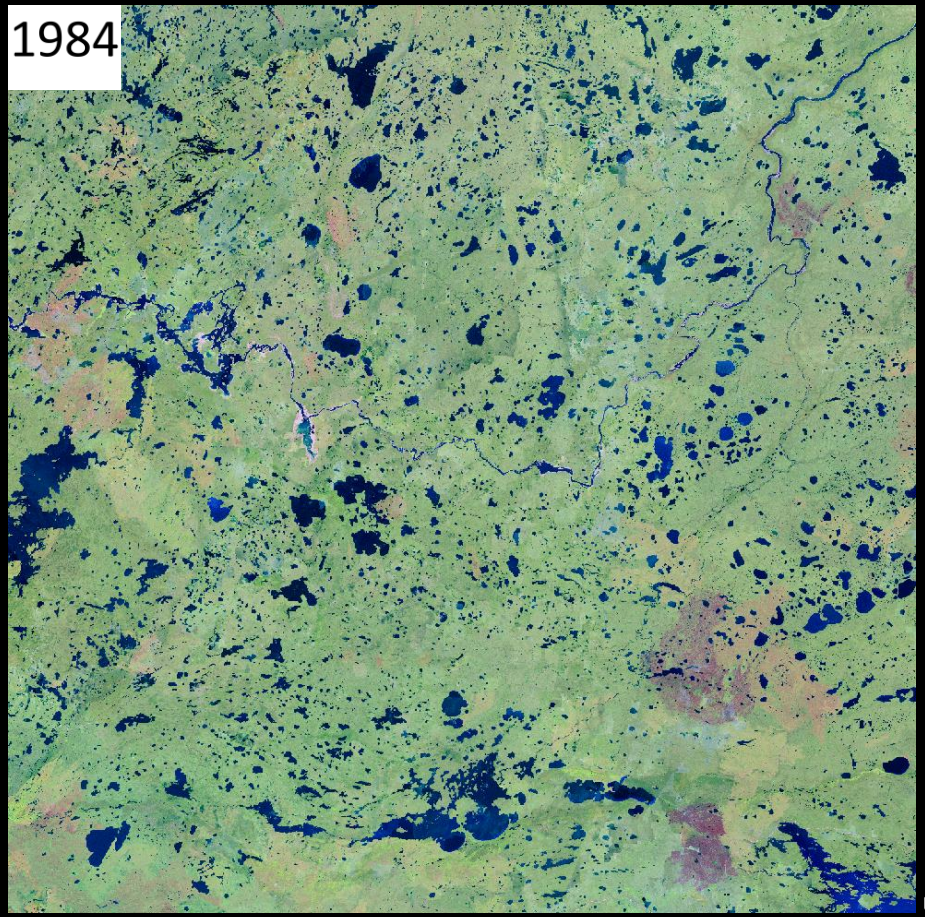
New Brunswick

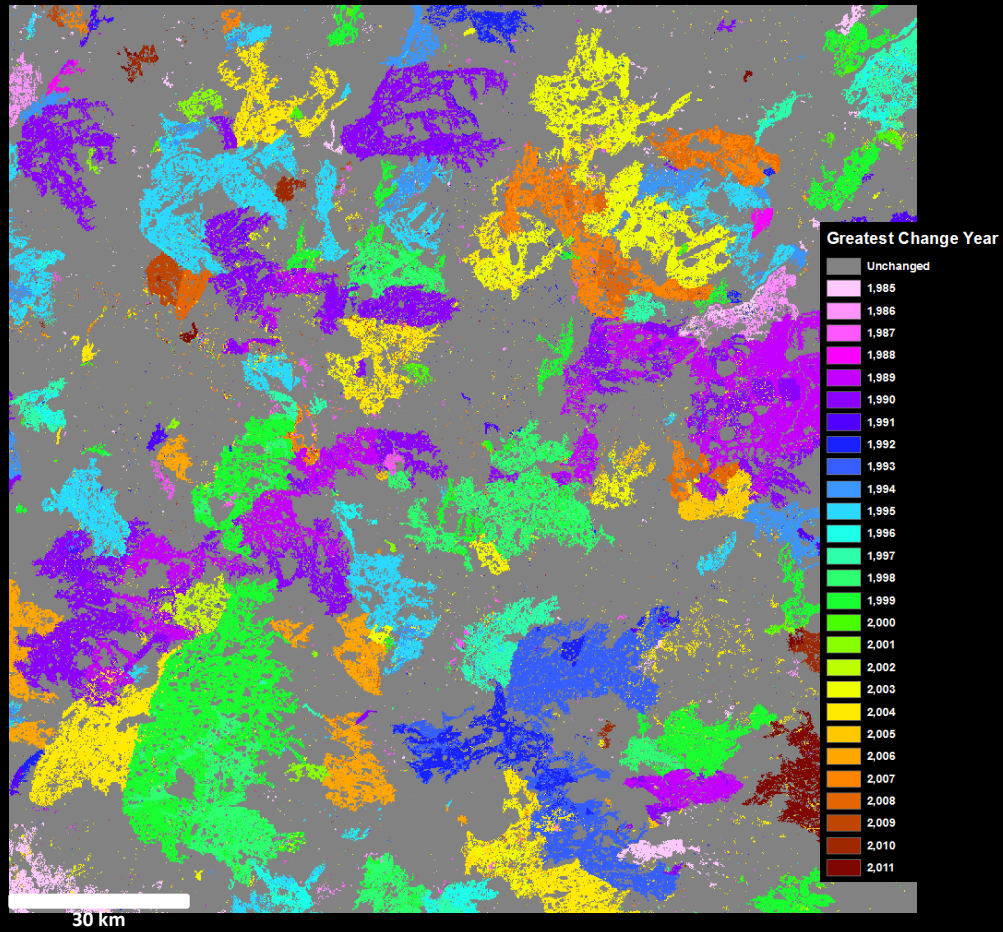


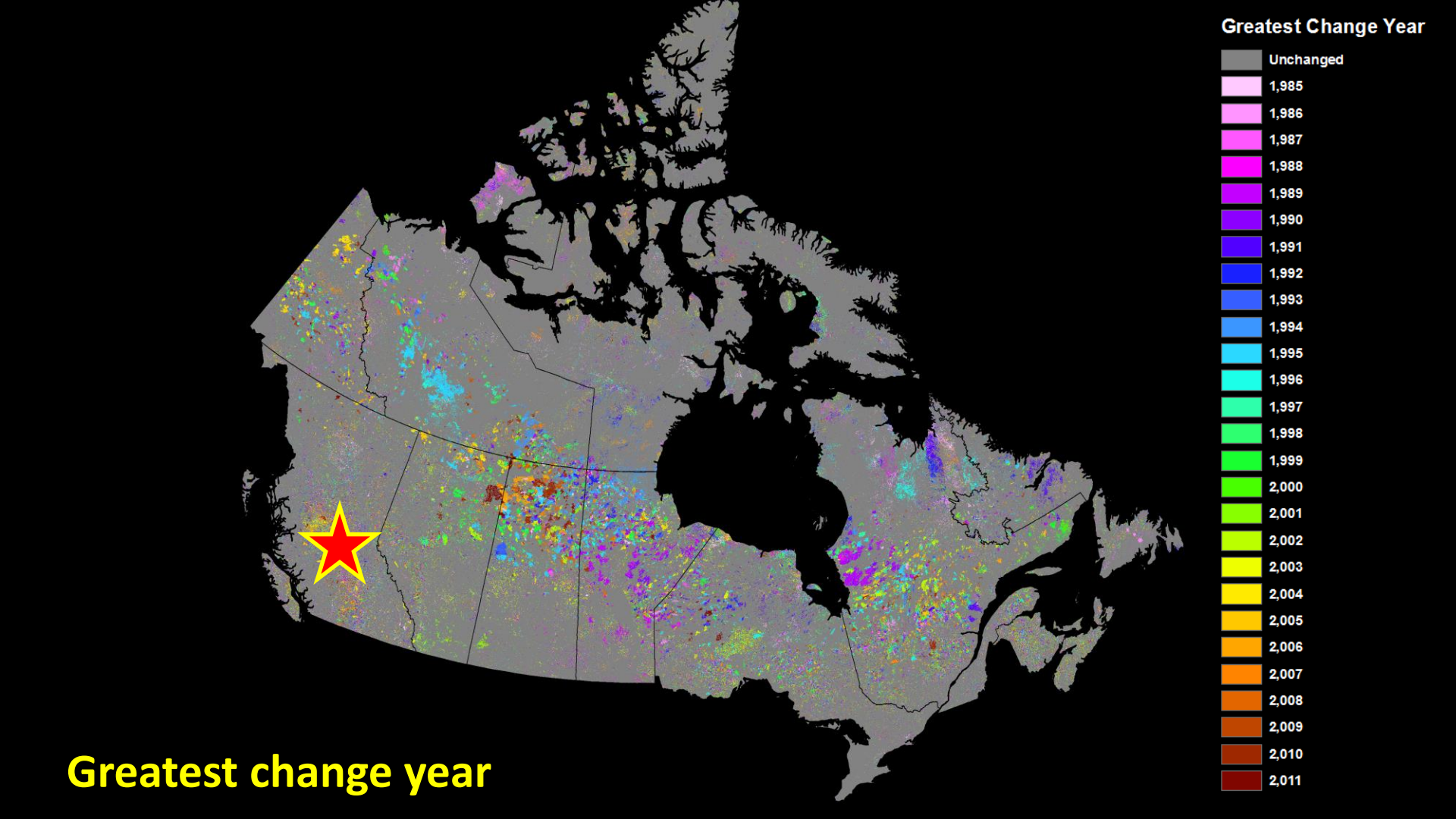



Greatest Change Year
Unchanged
1,985
1,986
1,987
1,988
1,989
1,990
1,991
1,992
1,993
1,994
1,995
1,996
1,997
1,998
1,999
2,000
2,001
2,002
2,003
2,004
2,005
2,006
2,007
2,008
2,009
2,010
2,011
Greatest change year

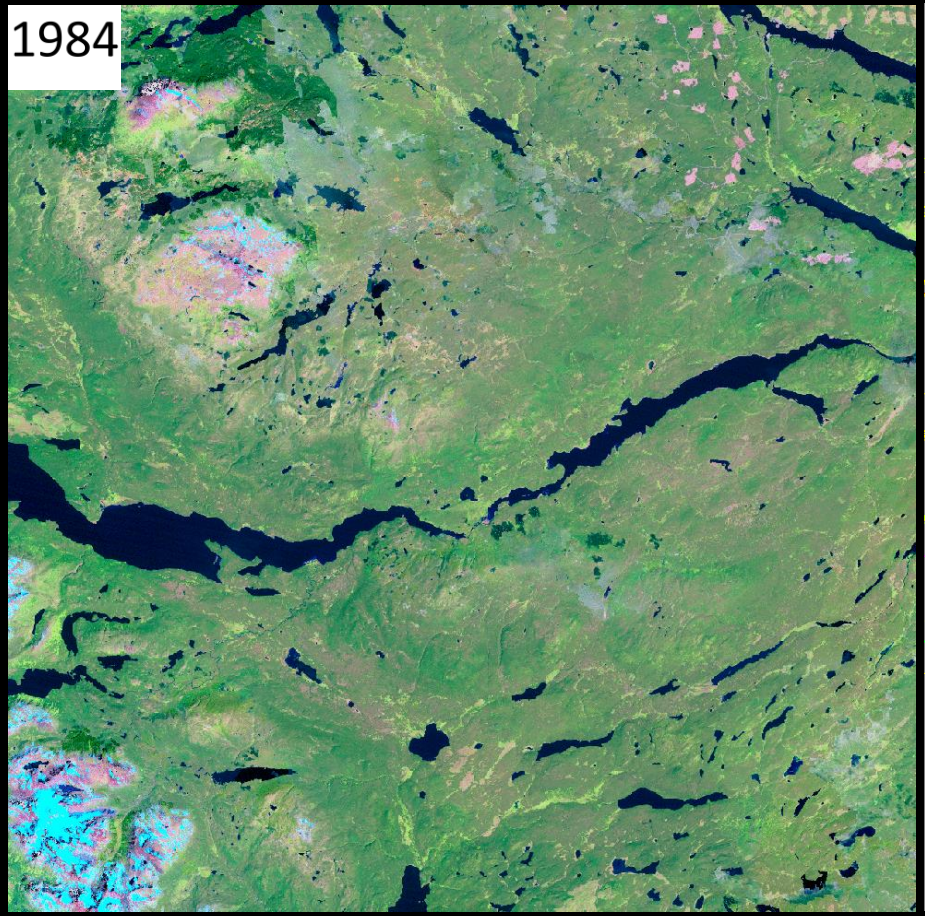
Manitoba

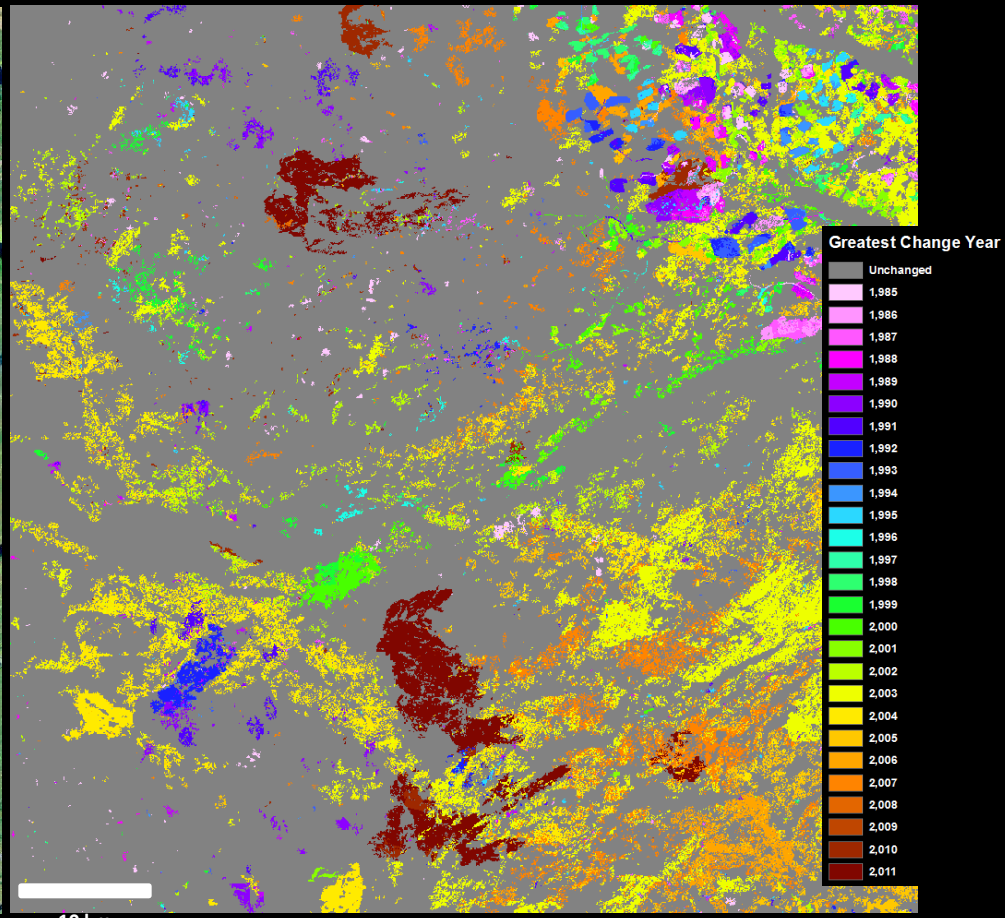

1984


Greatest Change Year
Unchanged
1,985
1,986
1,987
1,988
1,989
1,990
1,991
1,992
1,993
1,994
1,995
1,996
1,997
1,998
1,999
2,000
2,001
2,002
2,003
2,004
2,005
2,006
2,007
2,008
2,009
2,010
2,011
30 km

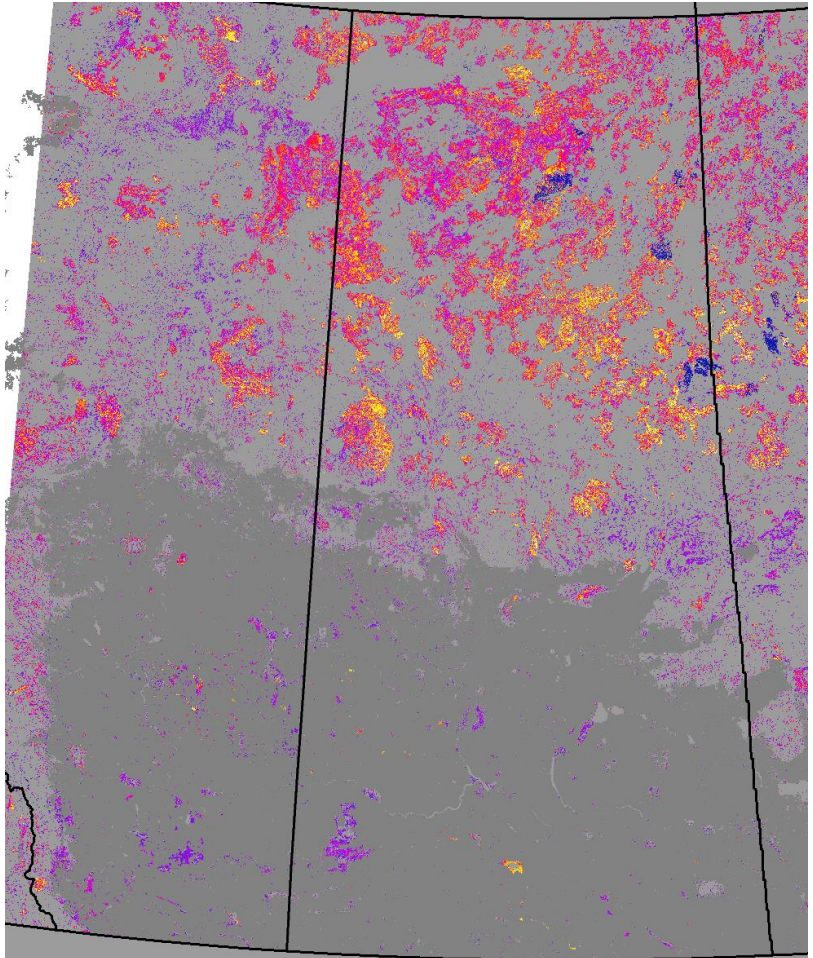

Greatest Change Year
Unchanged
1,985
1,986
1,987
1,988
1,989
1,990
1,991
1,992
1,993
1,994
1,995
1,996
1,997
1,998
1,999
2,000
2,001
2,002
2,003
2,004
2,005
2,006
2,007
2,008
2,009
2,010
2,011
Greatest change year

British Columbia





Change detection outputs



Change magnitude variation

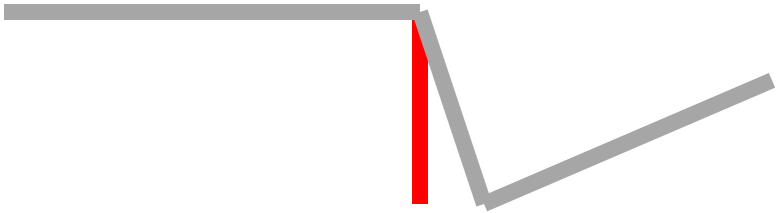
0

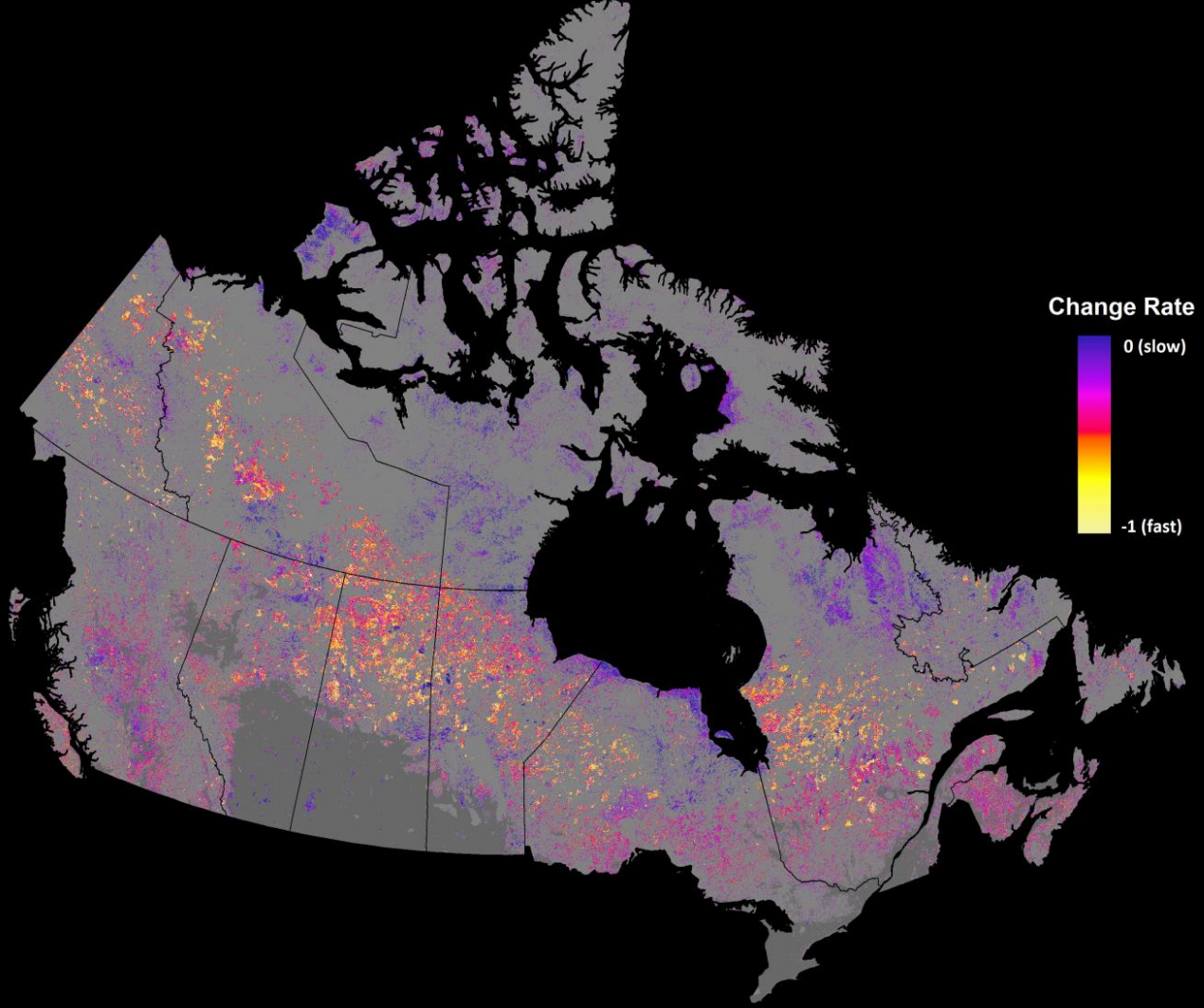
-1.3

Unchanged

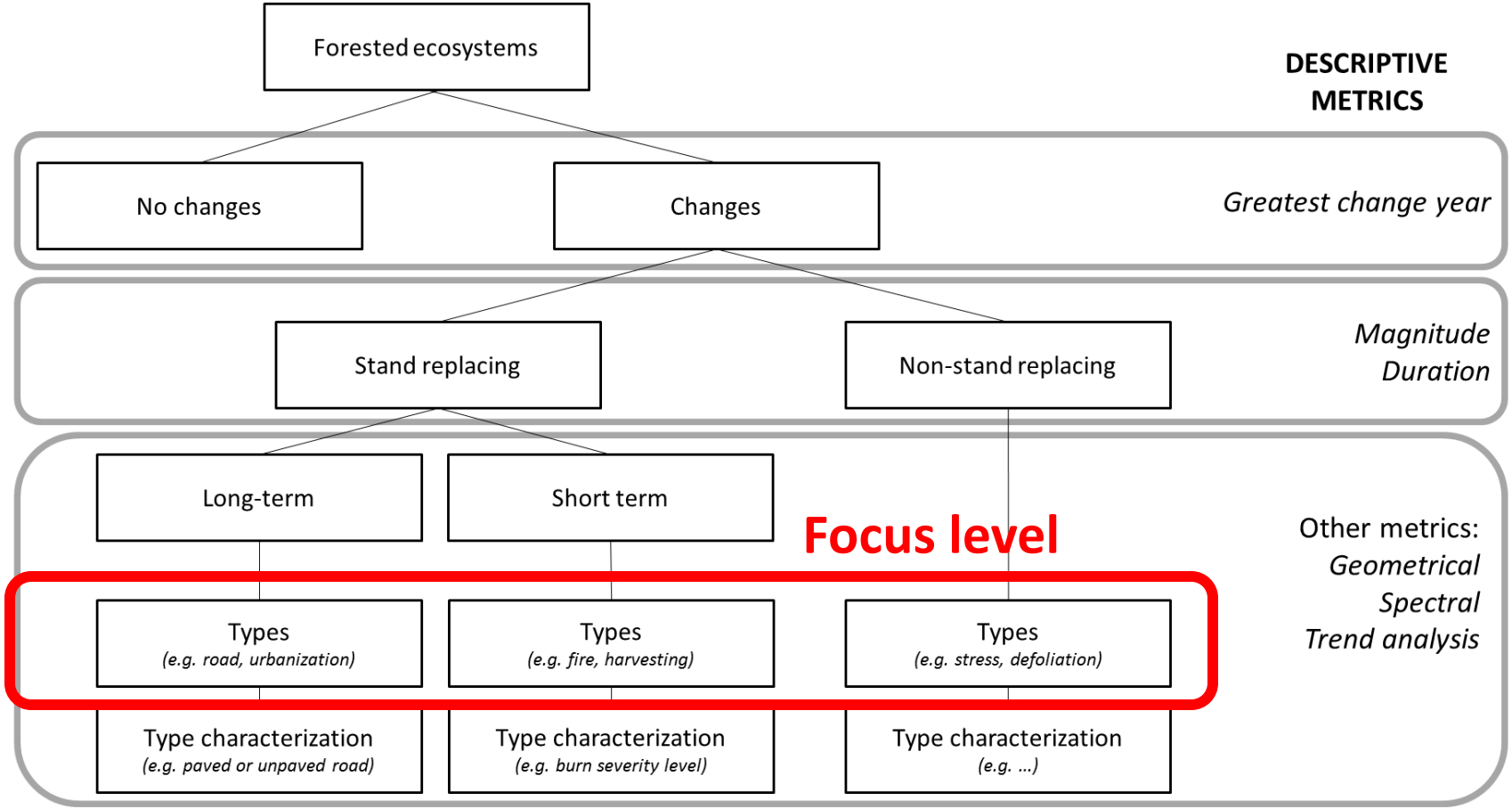
Agricultural areas

	Metric
Pre-change	Pre-change magnitude variation
	Pre-change persistence
	Pre-change evolution rate
Change	Change year
	Change persistence
	Change magnitude variation
	Change rate
Post-change	Post-change magnitude variation
	Post-change persistence
	Post-change evolution rate

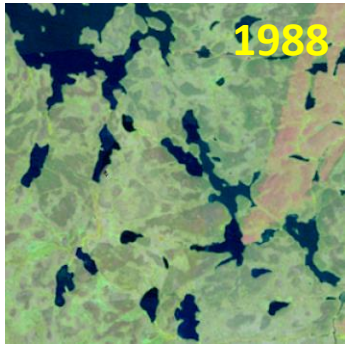


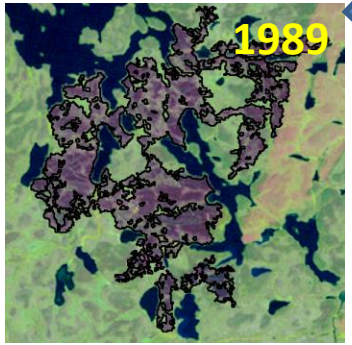

Change Rate
0 (slow)
-1 (fast)

Hierarchy of change

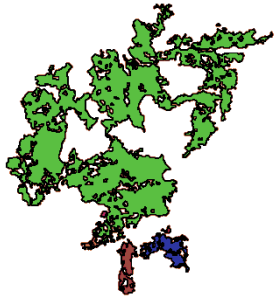


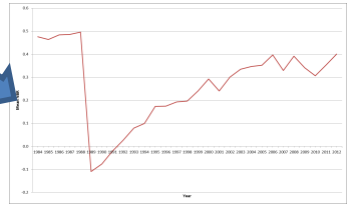
Change attribution





Descriptive Metrics





Geometry

- Area
- Perimeter
- Compactness
- Shape index
- Fractal dimension

Spectral

- Average spectral value pre-change
- Average spectral value post-change
- Standard deviation value post-chang
- Average pixel series value b4, b5, b
- Standard deviation of pixel series va
- Range of pixel series values b4, b5,

Trend analysis

- Duration
- Average change magnitude varia
- Pre-change magnitude variation
- Pre-change duration
- Pre-change evolution rate NBR
- Post-change magnitude variation NBR
- Post-change duration
- Post-change evolution rate NBR

Random Forest

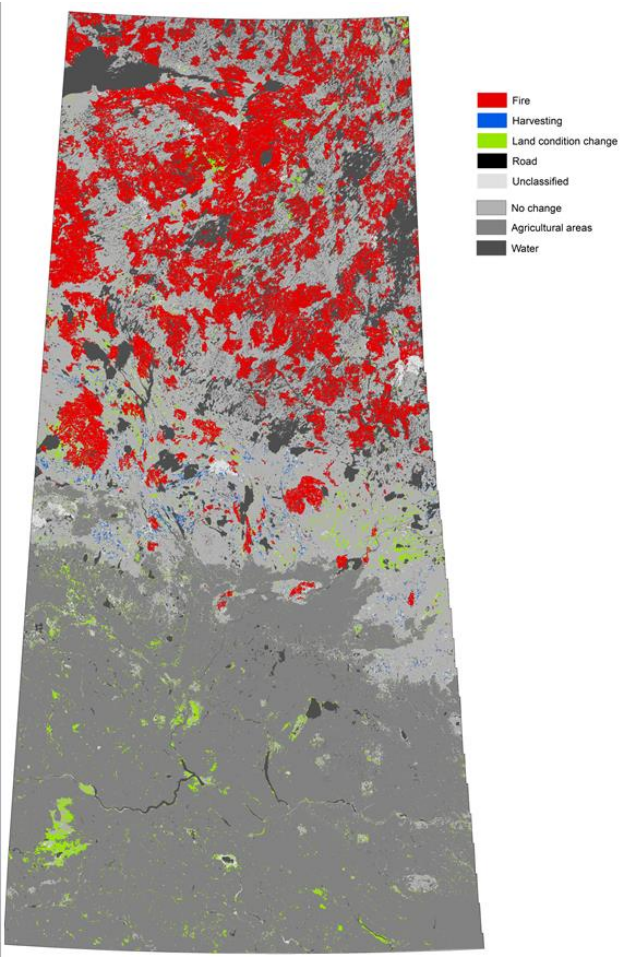
Categories:

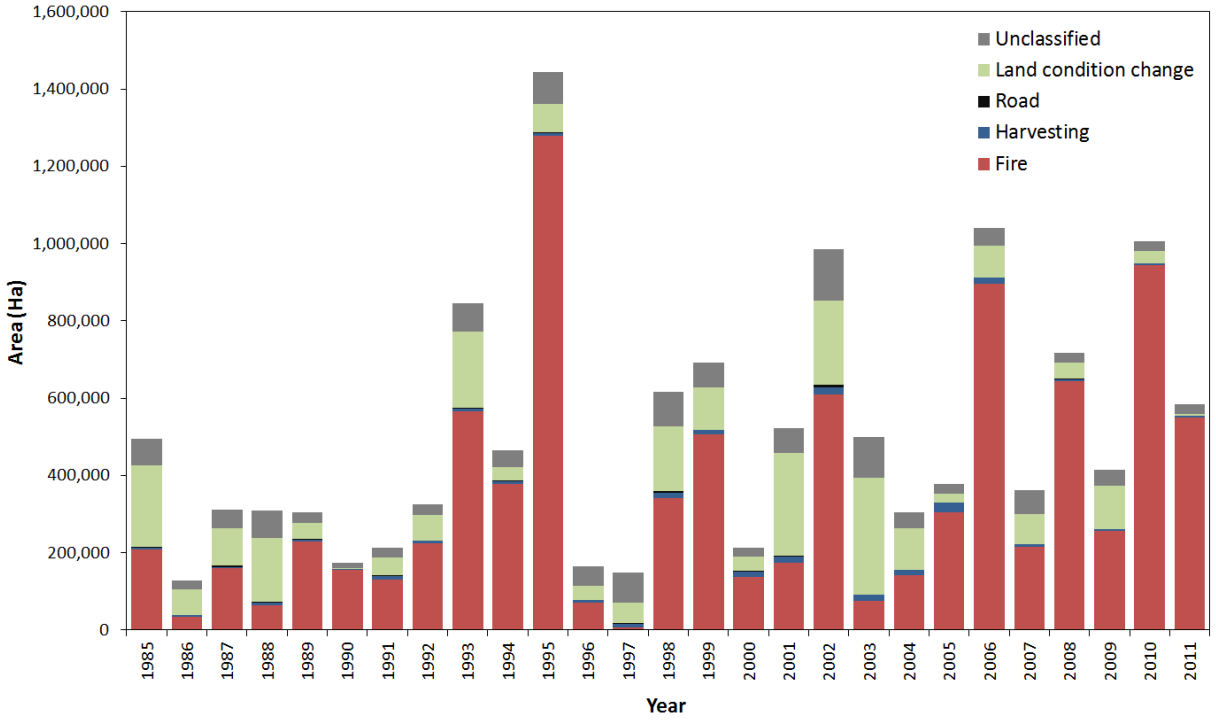
Fire
Harvesting
Road
Land condition change

Low confidence attributions:

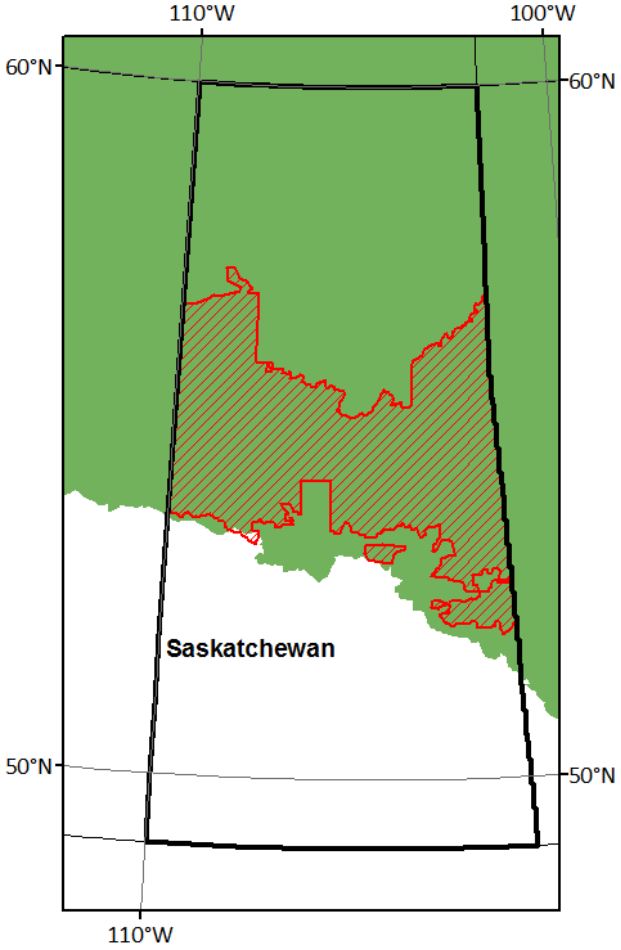
Unclassified

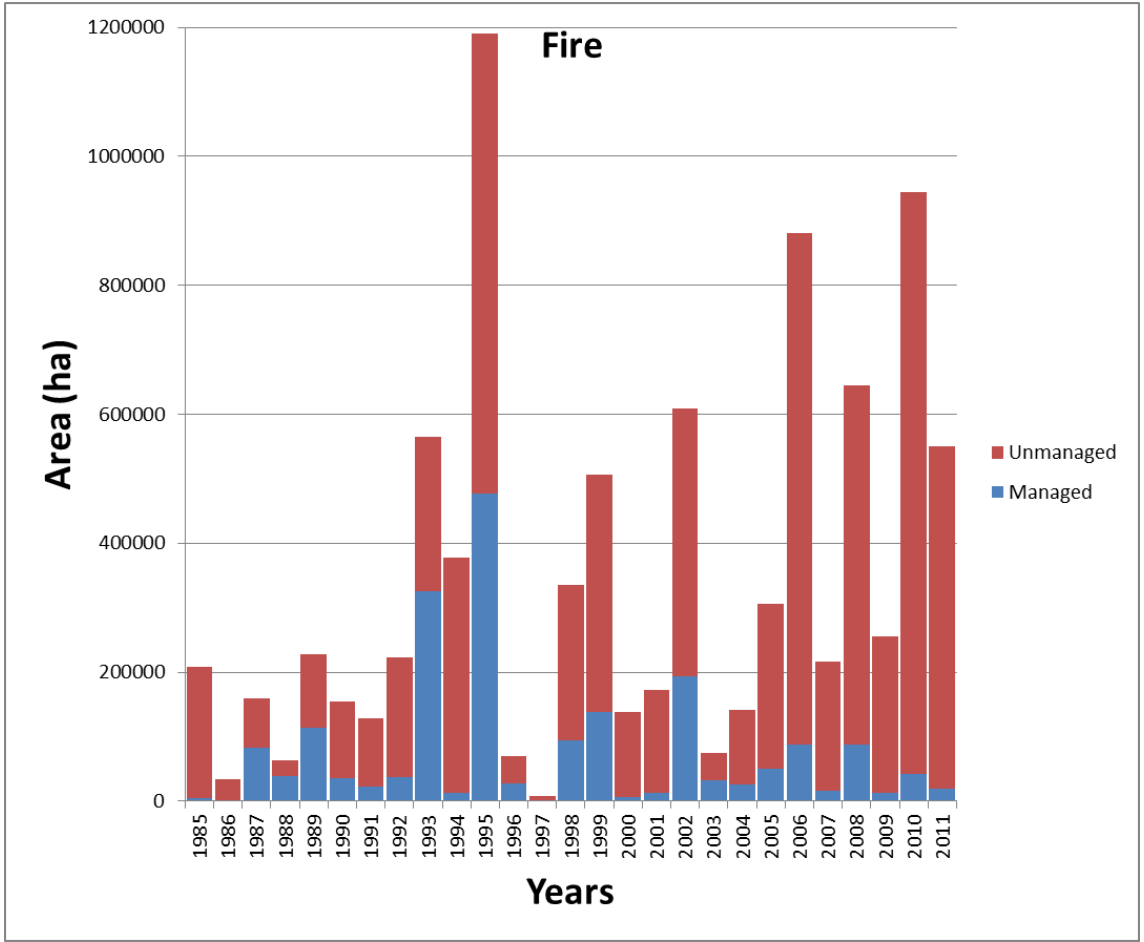
Change attribution results (SK)



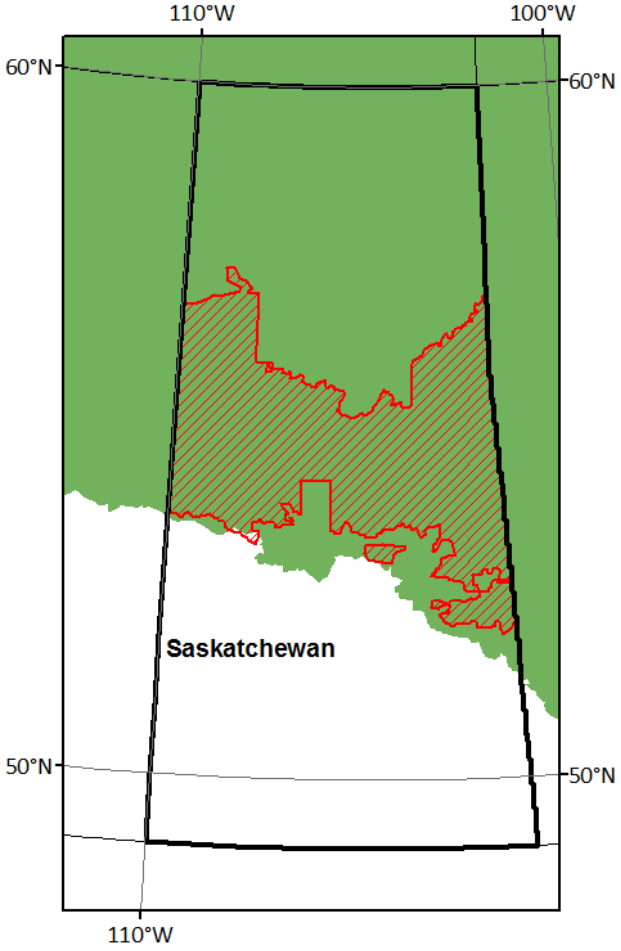


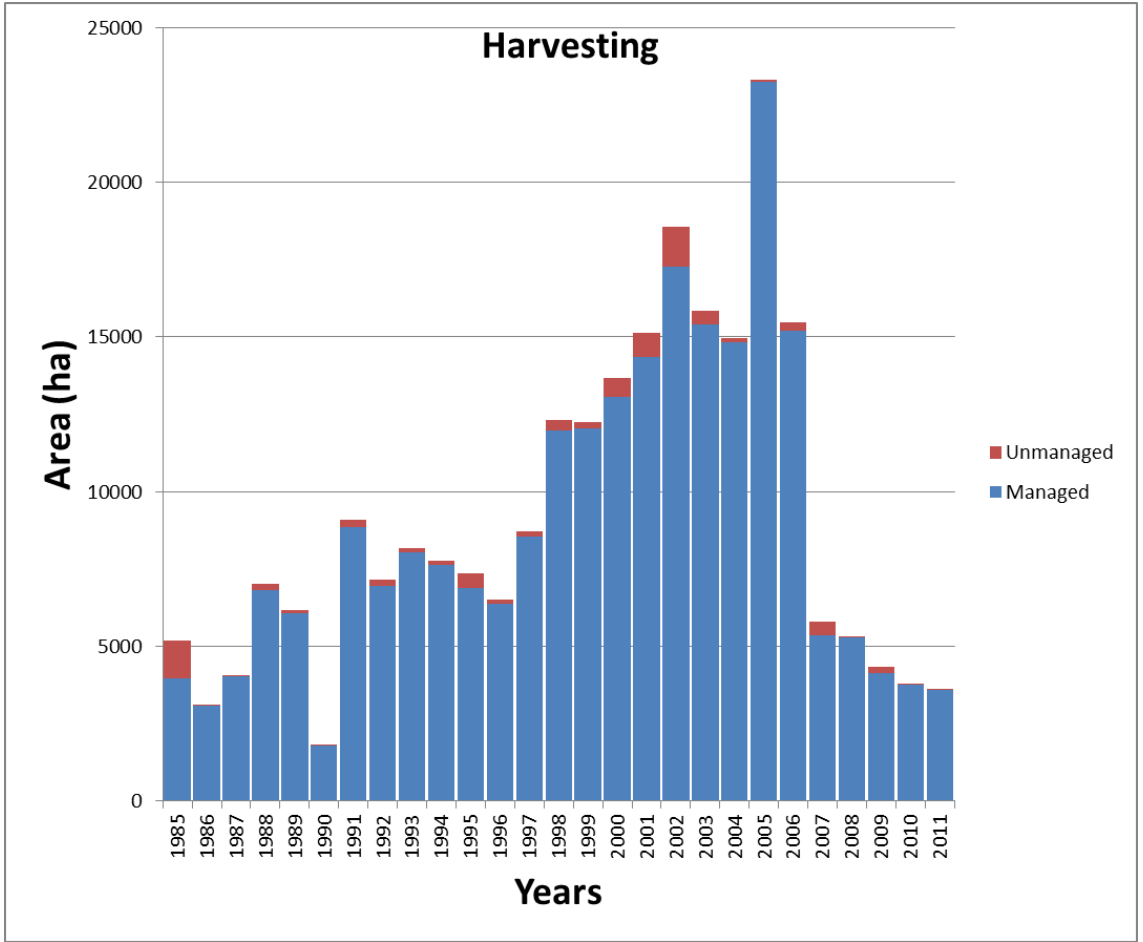
Change attribution results (SK)





Change attribution results (SK)





Preliminary validation results (SK)

What is the accuracy of the <u>change detection</u> (change/no change)?

91.06% (±2.09%)

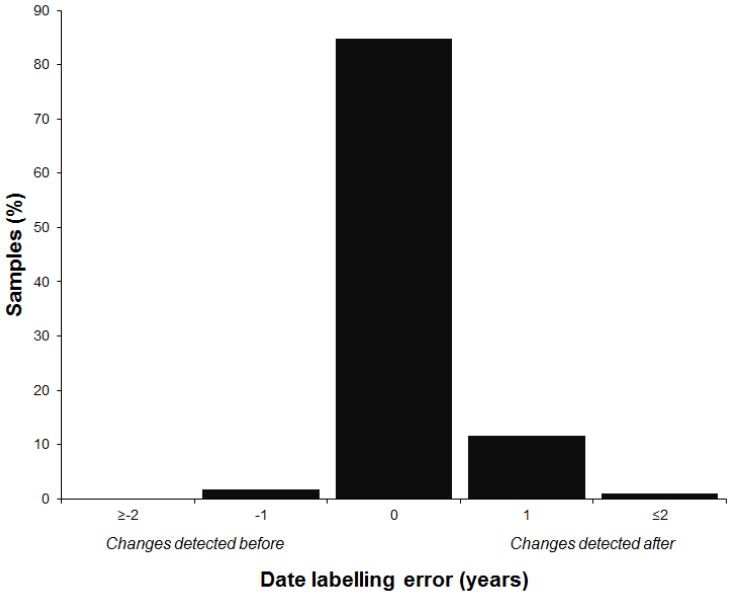
Is the change detected in the correct <u>year</u>?

85% to correct years

11%: +1 Year

1.8%: -1 Year

98.4% are labelled to within ± 1 year of their actual change year



Preliminary validation results (SK)

Are the change events assigned to the correct <u>change type</u> (*Object-level*)?

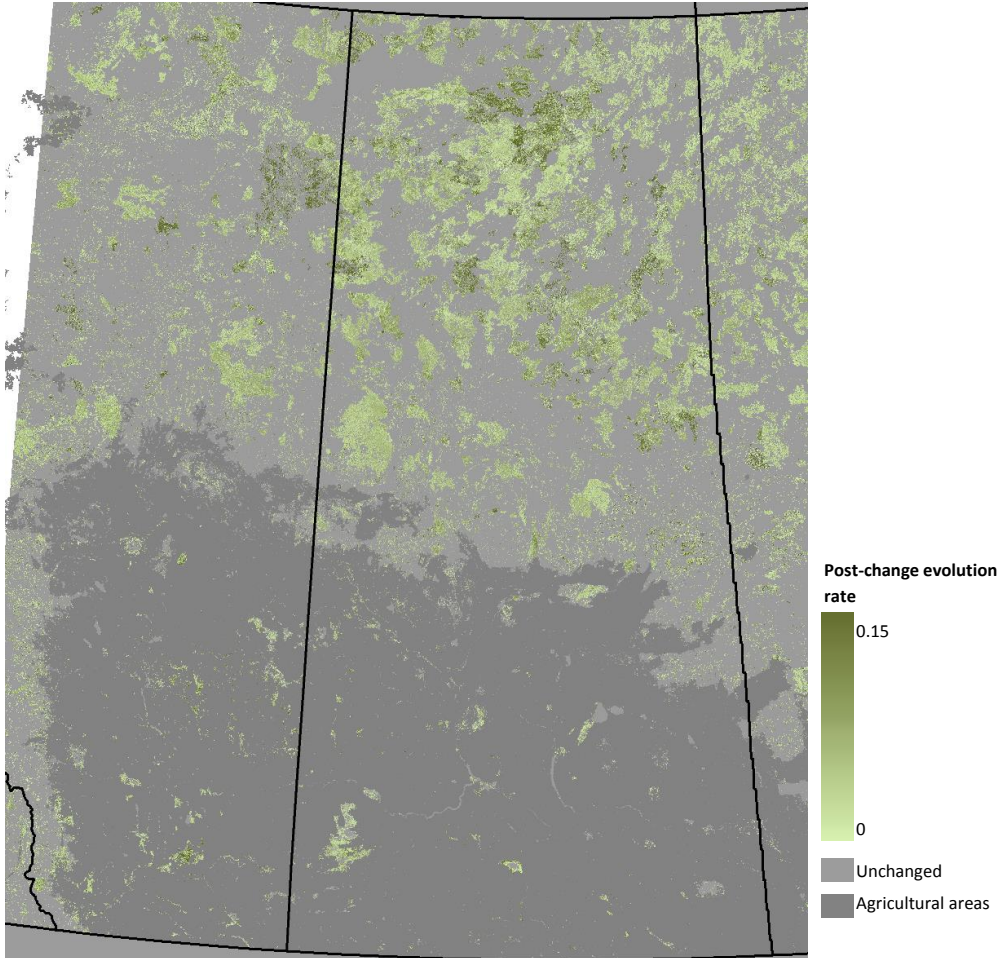
91.60% (±2.1%)

Do the change events accurately estimate the <u>area</u> of change?

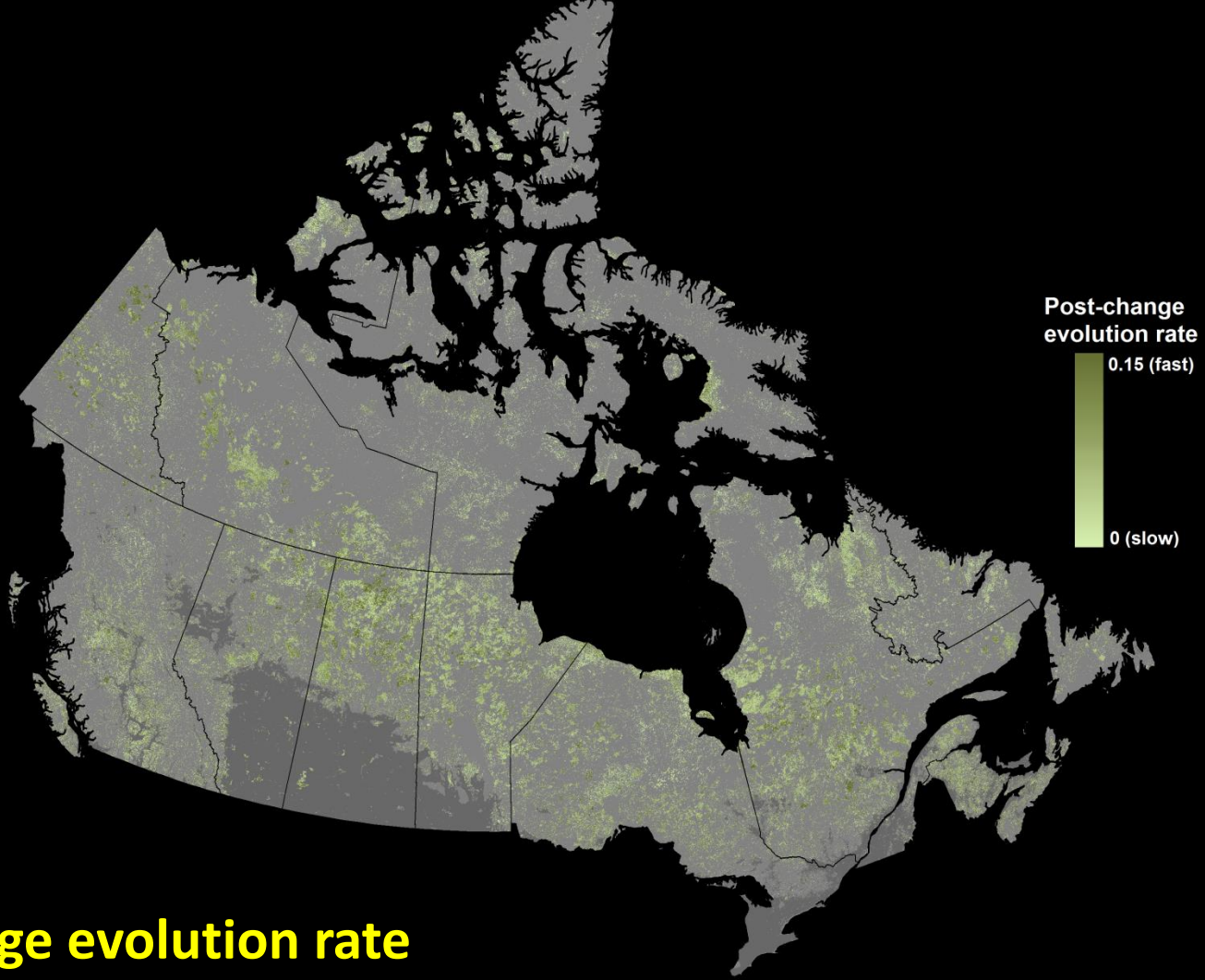
98.0 % (±1.1%)

Methods after: Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E. and Wulder, M. A. (2014). Good Practices for Assessing Accuracy and Estimating Area of Land Change. Remote Sensing of Environment. 148:42-57. LINK

Change detection outputs

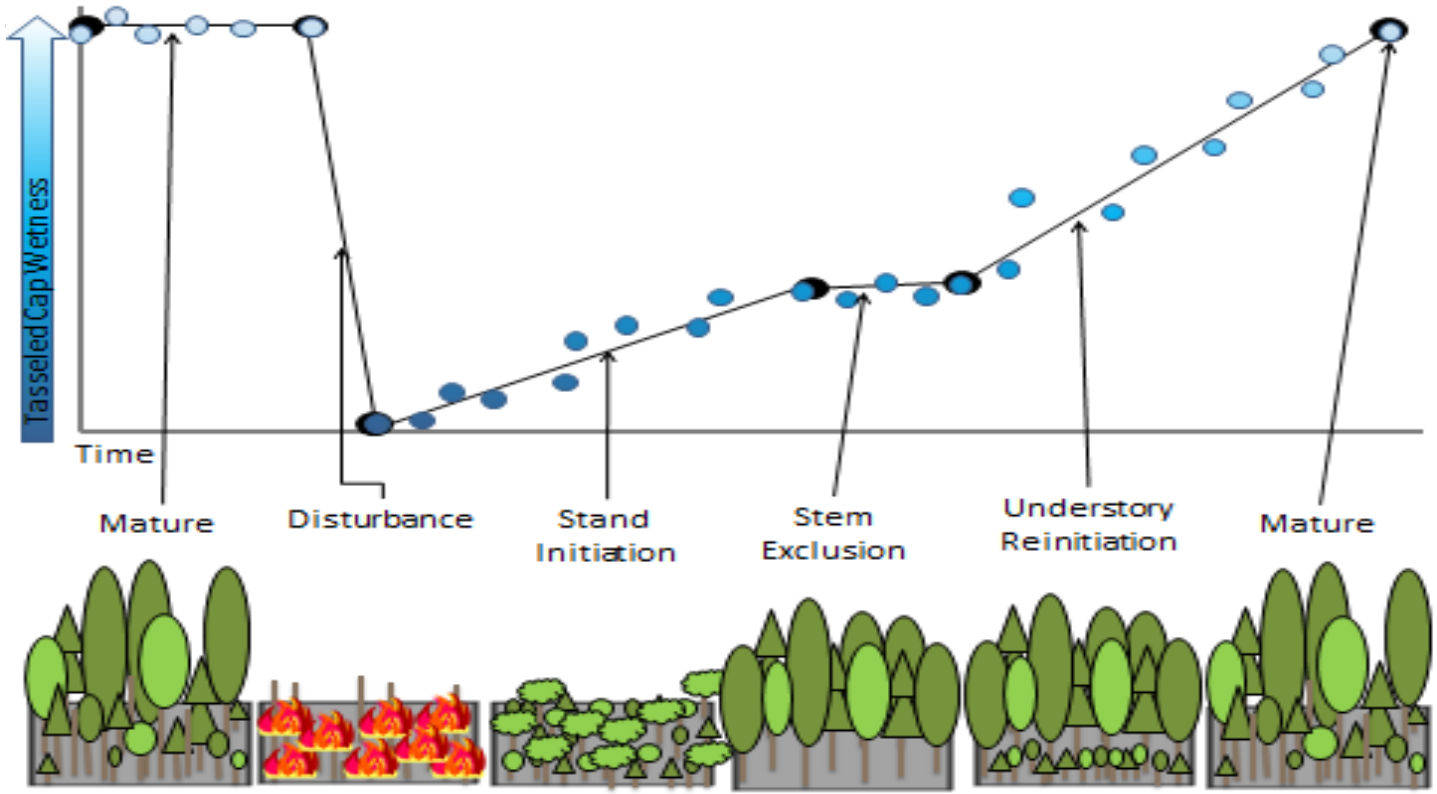


	Metric
Pre-change	Pre-change magnitude variation
	Pre-change persistence
	Pre-change evolution rate
Change	Change year
	Change persistence
	Change magnitude variation
	Change rate
Post-change	Post-change magnitude variation
	Post-change persistence
	Post-change evolution rate



Post-change evolution rate

(Spectral) Forest recovery



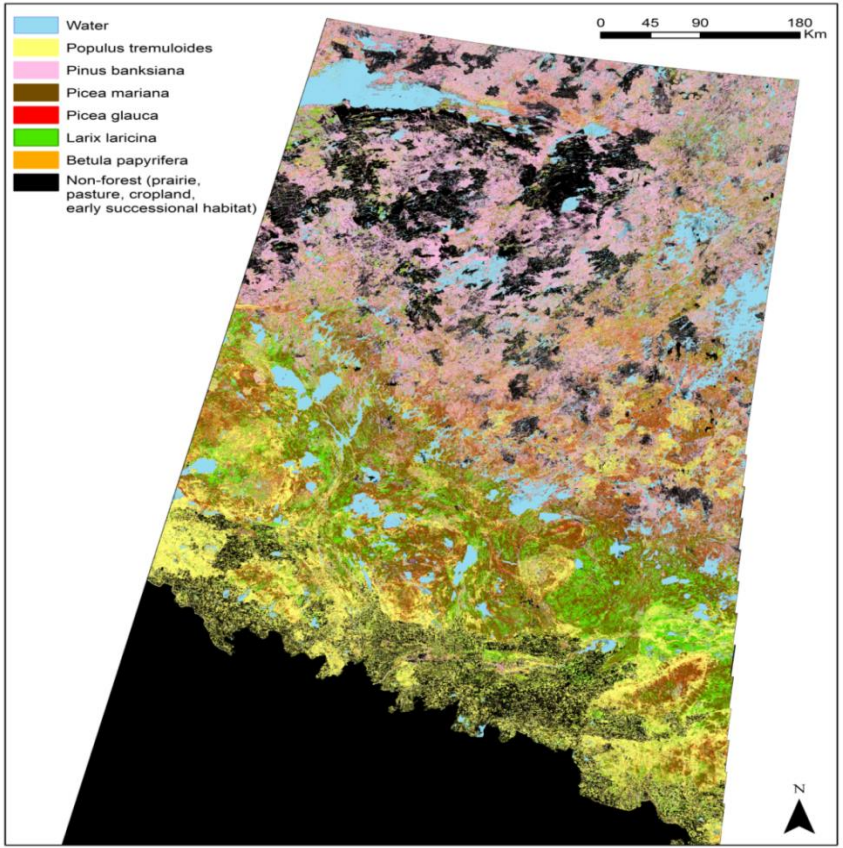
R. Frazier, UBC

Thoughts on recovery

- Terminology
  - What is it?
  - What do we want to know?
- Process, not a state
- Perspectives:
  - Ecological
  - Silvicultural
  - Spectral
- Latency required?
  - Return to previous condition
  - Demonstration of regen
- Satellite record
  - 30 to 40 yrs
    - Plus, need a window prior to end date
  - Vegetation return, re-establishment
- Chronosequence

Current work

- **Tree species modelling**
  - Spatial pattern analyses indicated that the BAP had little impact on species composition and configuration
- Land cover
- Biomass, volume, ht
  - Imputation using lidar-plots
- Incorporate L8, S2



Thompson, S.D., Nelson, T.A., White, J.C., Wulder, M.A. (2015). Mapping dominant tree species over large forested areas using Landsat best-available-pixel image composites. Canadian Journal of Remote Sensing. In press (May 2015)

THE UNIVERSITY OF BRITISH COLUMBIA

Natural Resources Canada

Ressources naturelles Canada

Thanks!

Mike Wulder

mwulder@nrcan.gc.ca

@mikewulder