Change Detection

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ESA TRAINING COURSE ON RADAR AND OPTICAL REMOTE SENSING –
Vilnius/LITHUANIA, 3-7 July, 2017

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Definition

“Change detection for GIS is a process that measures how the attributes of a particular area have changed between two or more time periods. Change detection often involves comparing aerial photographs or satellite imagery of the area taken at different times. The process is most frequently associated with environmental monitoring, natural resource management, or measuring urban development”

Change Detection Analysis encompasses a broad range of methods used to identify, describe, and quantify differences between images of the same scene at different times or under different conditions.

Data needed for Change Detection:

→ Images from the same are but from different dates

→ Images can be thematic or continuous

→ data values must be comparable

Visual Interpretation vs. Technical Calculation

- Usable on continous (like satellite images) and on thematic data (e.g. classification)
- Mostly used only for continuous data
- Two images from the same area are needed
  - Change detection always based on change between different time periods → images from the same area bit different acquisition date are needed)

Example for Change Detection

Example for Change Detection

Technical Calculation

- Calculation of the difference between to layers
- For satellite image data choose the channel to compare
- For classification only one layer is available with all the information you need for change detection
- Divide an image with a newer date (after image) from an image with an older date (before image)

Real Changes vs. Mistaken Changes

- Real Change:
  - Change in land cover or land use for specified area
  - E.g. urban spreading
- Mistaken Changes:
  - Changes in class values but not in real land cover or land use
  - Difficult to distinguish → interpretation of change is needed
  - E.g. technical changes

- geometric shifts may lead to changes which also can be described as technical changes
- These are actually no changes but occur because of either mismatching data sets or the area was classified slightly differently in both dates so that the change product results in fringes

How to deal with Changes?

- According to the number of all pixels count major changes have taken place e.g. from Barren to Urban / Agriculture / Mangrove / Wetlands / Water / Grassland or Shrub and vice versa.
- But interpreting these results correctly it is recommended to keep some aspects in mind.
- The images examined mark just “snap-shots” between two specified dates and the characteristic of an image and the occurrence of a land use class respectively depends on what happened to that specific area up to the time of taking the picture. I.e.: was there a heavy rainfall beforehand or a dry or for coastal regions: was there high or low tide? Was this area just harvested or newly plant?

When performing a change detection analysis on non-thematic images (gray scale data), it is important to consider all of the factors that can cause scenes of the same area to look different. The following are a few notable factors:

- **Differences in the instrument or sensor** — Consider the similarity of the sensors that collected the images. Even bands collected in the same part of the spectrum (for example, two red bands) may have different band center wavelengths, or different spectral response functions, which can lead to different pixel values for the same material.

- **Differences in the collection date and time** – Seasonal changes can impart big differences in scenes containing vegetation (due to plant senescence and canopy architecture development). Differences in the season and time of day will also affect the solar azimuth and elevation.

- **Differences in Atmospheric Conditions** — The dominant weather conditions can affect atmospheric transmission and scattering. Consistent differences in gross atmospheric conditions are often associated with seasonal changes. For example, differences in the predominant wind direction can be important (winds blowing in over the ocean contain different aerosols with different scattering properties from those blowing in over an urban area). Another common, yet consistent, atmospheric difference is the water content of the atmosphere. Summer atmospheres tend to be wetter than winter atmospheres. Atmospherically corrected images can reduce such influences.

- **Differences in Image Calibrations** – For the most accurate change detection results, it is important to work with images that are calibrated into the same units. If a calibration into physical units (such as radiance) is not possible, a relative calibration may be better than none at all (especially if the instruments that collected the images have different dynamic ranges).

- **Differences in Image Resolution** – Differing pixel sizes can lead to false change detections. It is important that the original images (prior to resampling or re-projection) have the same pixel resolution. For scenes with large swaths (such as AVHRR, SeaWiFS, or MODIS) the actual pixel sizes differ across the scene. In such cases, differences in the sensor viewing geometry can also be important.

- **Coregistration Accuracy** — Accurately coregistered images are critical for change detection analyses. While the **Compute Difference Map** routine will automatically coregister the input images using the available map information, if the differences in the image geometry are substantial, it is well worth the effort to ensure that the coregistration is as accurate as possible before performing a change detection

Difference Maps Input Parameters

Percent Difference File:

The simple difference divided by the initial state value.

Simple Difference File:

Subtracts the initial state image from the final state image

Normalization:

Subtracts the image minimum and

dividing by the image data range: Normalization =

(DN - min) / (max - min).

Standardization:

Subtracts the image mean and

dividing by the standard deviation: Standardization =

(DN - mean) / stdev.

Difference Maps Input Parameters

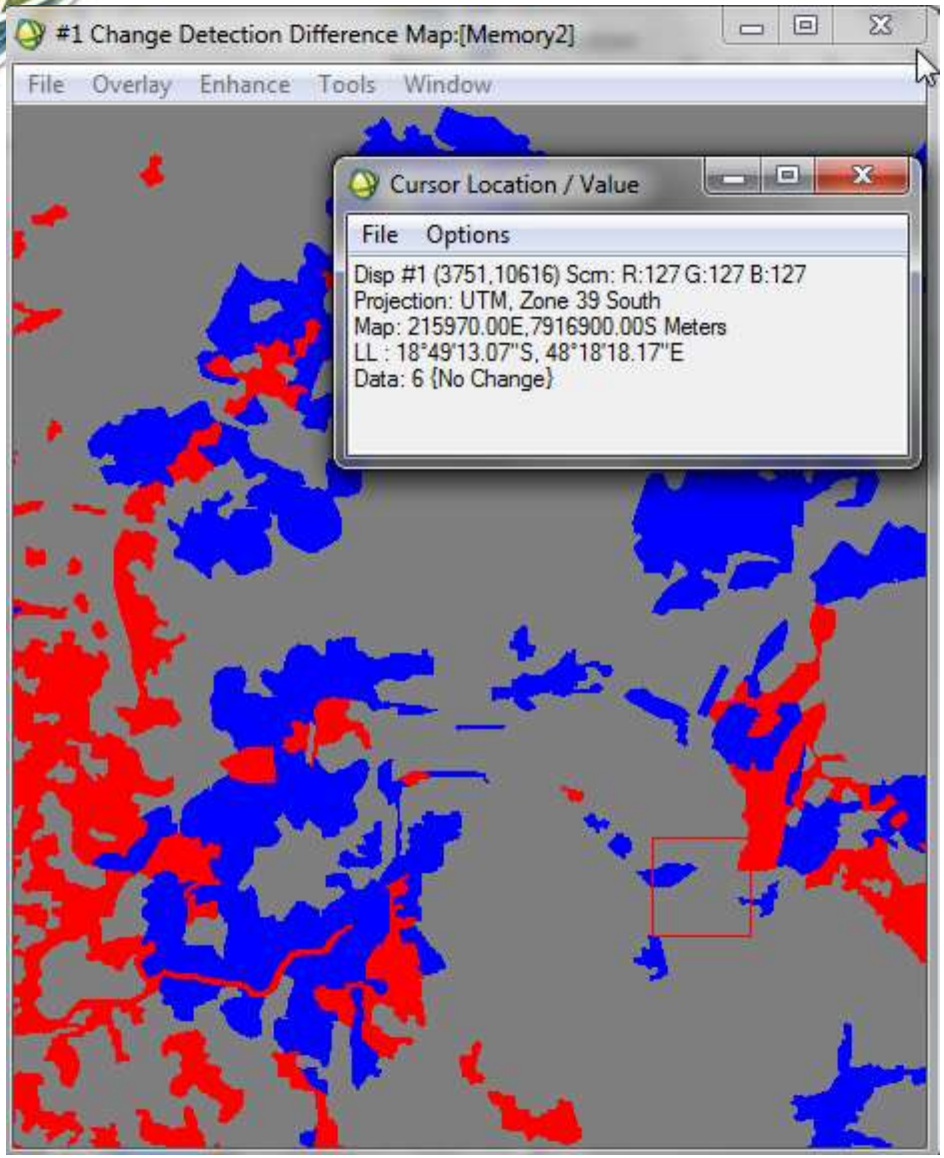
As Percent

Click the As Percent button to see the changes in brightness as a percent. The As Percent option works well with continuous data images.

As Value

Click the As Value button to see the changes in brightness as a direct result of subtraction. The As Value option works well with GRID data, like evaluation values.

Producing Change Detection Maps



- Result: Simple Change Map
- Grey: No Change
- Blue: Change in lower class
- Red: Change in upper class

Note

- Mostly to difficult to see alle the changes in one image → create change maps for different issues
  - Recode the Classes you want to investigate
  - E.g. urban and no urban classification from two periodes and calculate
- Interpret the result

- Same class codes are given
- Multiply the before image with ten
- Addition of the two images

First image		+ second image =	result	
1	10	1	11 →	Class 1 in first and second = no change
2	20	2	12 →	Class 1 in first, class 2 in second = change
3	30	3	13 →	Class 1 in first, class 3 in second = change
4	40	4	14 →	Class 1 in first, class 4 in second = change
5	50	5	15 →	Class 1 in first, class 5 in second = change
6	60	6	16 →	Class 1 in first, class 6 in second = change
7	70	7	17 →	Class 1 in first, class 7 in second = change
8	80	8	18 →	Class 1 in first, class 8 in second = change
9	90	9	19 →	Class 1 in first, class 9 in second = change
			20 →	Class 2 in first, class 0 in second = tech. change

Image-to-Image Analysis

- provides a way to compare imagery collected over the same area at different times and to highlight features that have **changed**

- There are two forms of **change** detection:
  – absolute and
  – relative

- Absolute **change** detection highlights specifically what has **changed**, e.g. forest to grassland.

- Relative **change** detection shows that something has **changed** but does not specify what that **change** is. Relative **change** detection provides a faster method for quickly comparing images

types of relative change detection

- **Transform:**

Input datasets are stacked into one image cube, then an image transform (principle component analysis, minimum noise fraction, or independent components analysis) is applied in order to extract the feature correlating to **change**.

- **Subtractive:**

Normalized Difference Vegetation Index (NDVI), red/blue ratio, and man-made ratio are calculated for the input datasets. The resulting ratios and input bands are subtracted from the input images to create difference images.

types of relative change detection

- **Two Color Multi-View (2CMV):**

One band from the Time 1 image is displayed in the red band, and the same band in the Time 2 image is displayed in the green and blue bands. Objects that display a difference that is brighter from one image to the other appear in cyan. Objects that display a difference that is darker from one image to the other appear in red. The colors can then be used to indicate potential areas of **change**.

- **Spectral Angle:**

This method computes the spectral angle between corresponding pixel spectra in the Time 1 and Time 2 images. The spectral angle measures the spectral similarity between the two spectra.

SPEAR Change Detection tool

Two Color Multi-View (2CMV):

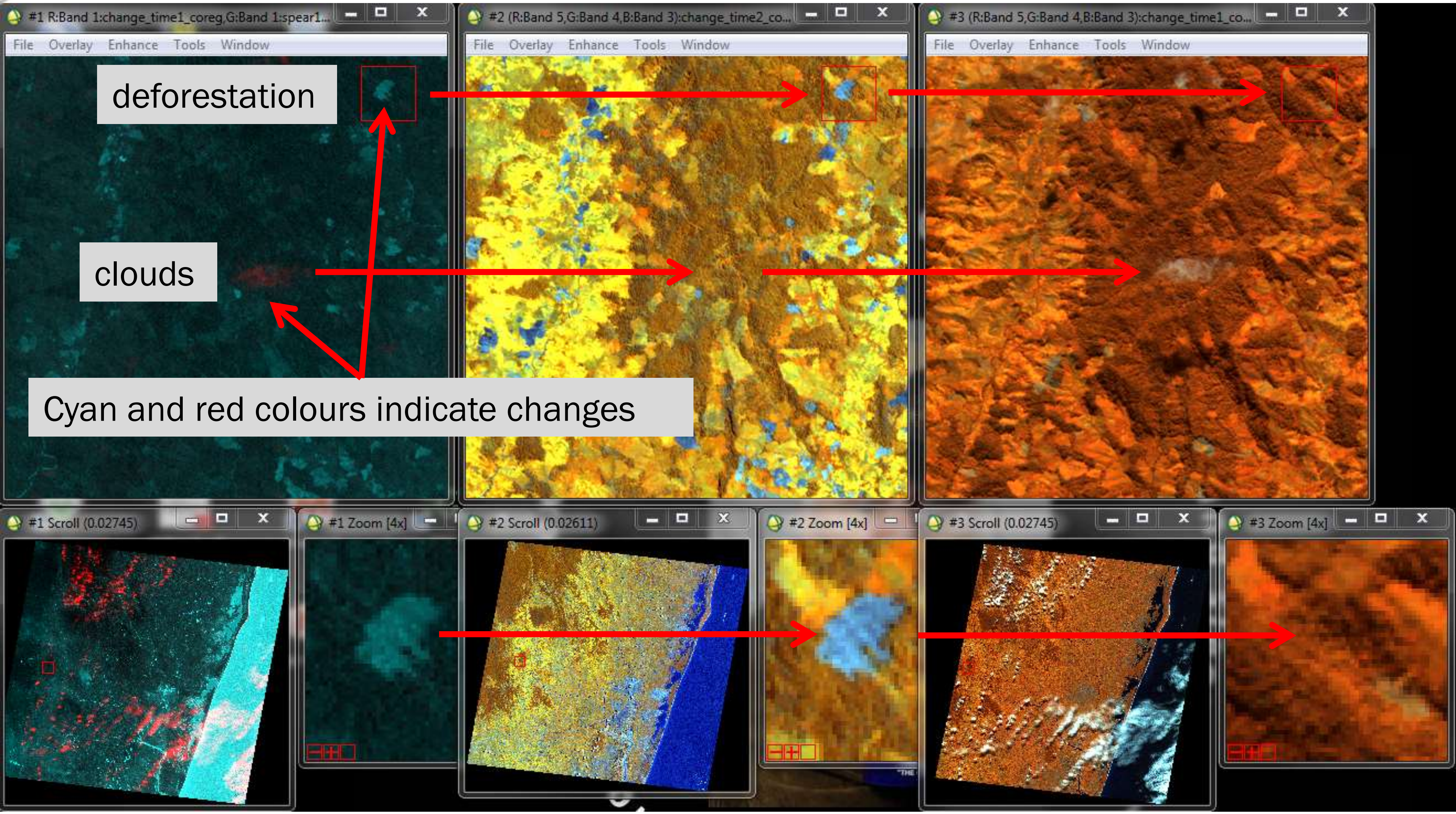
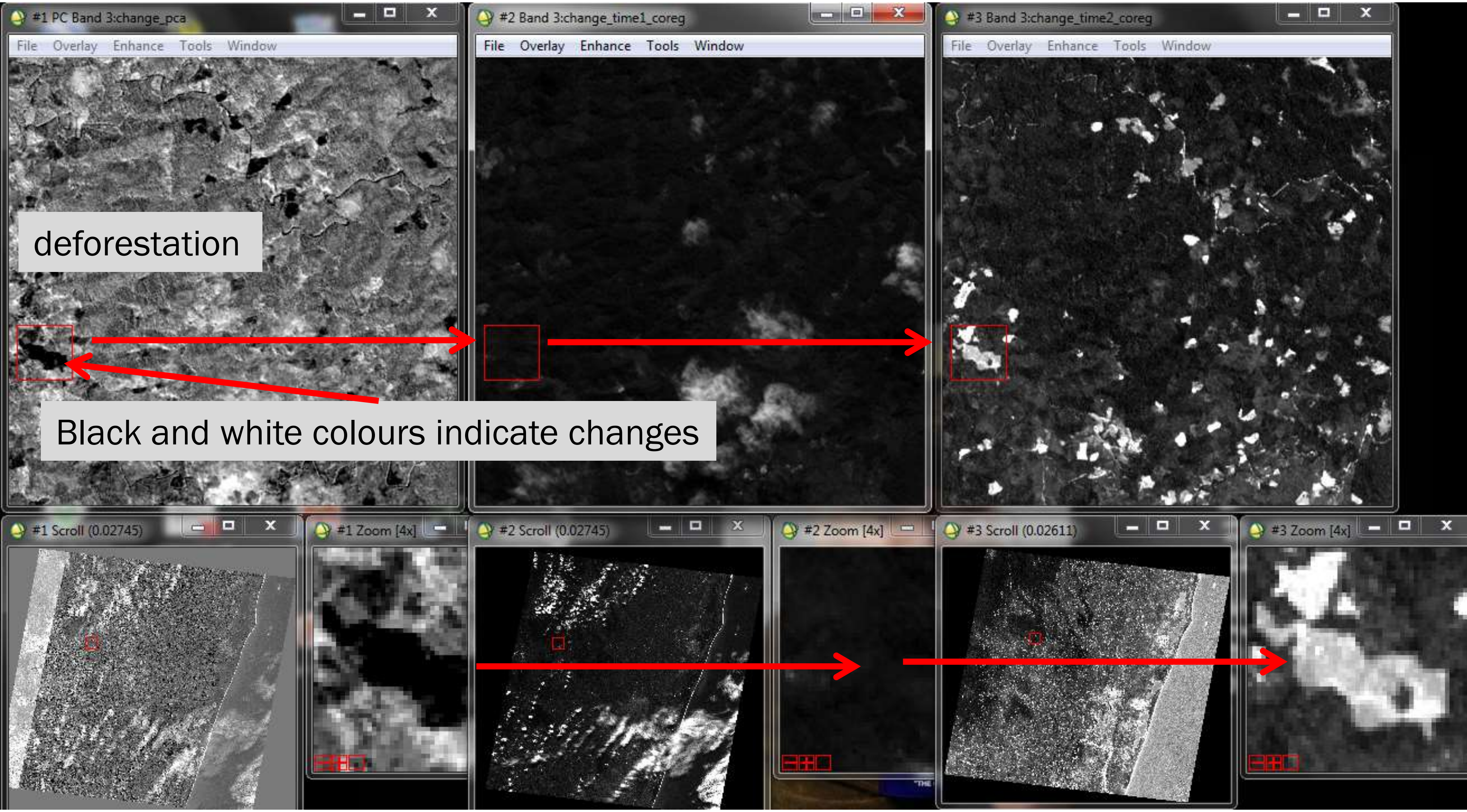
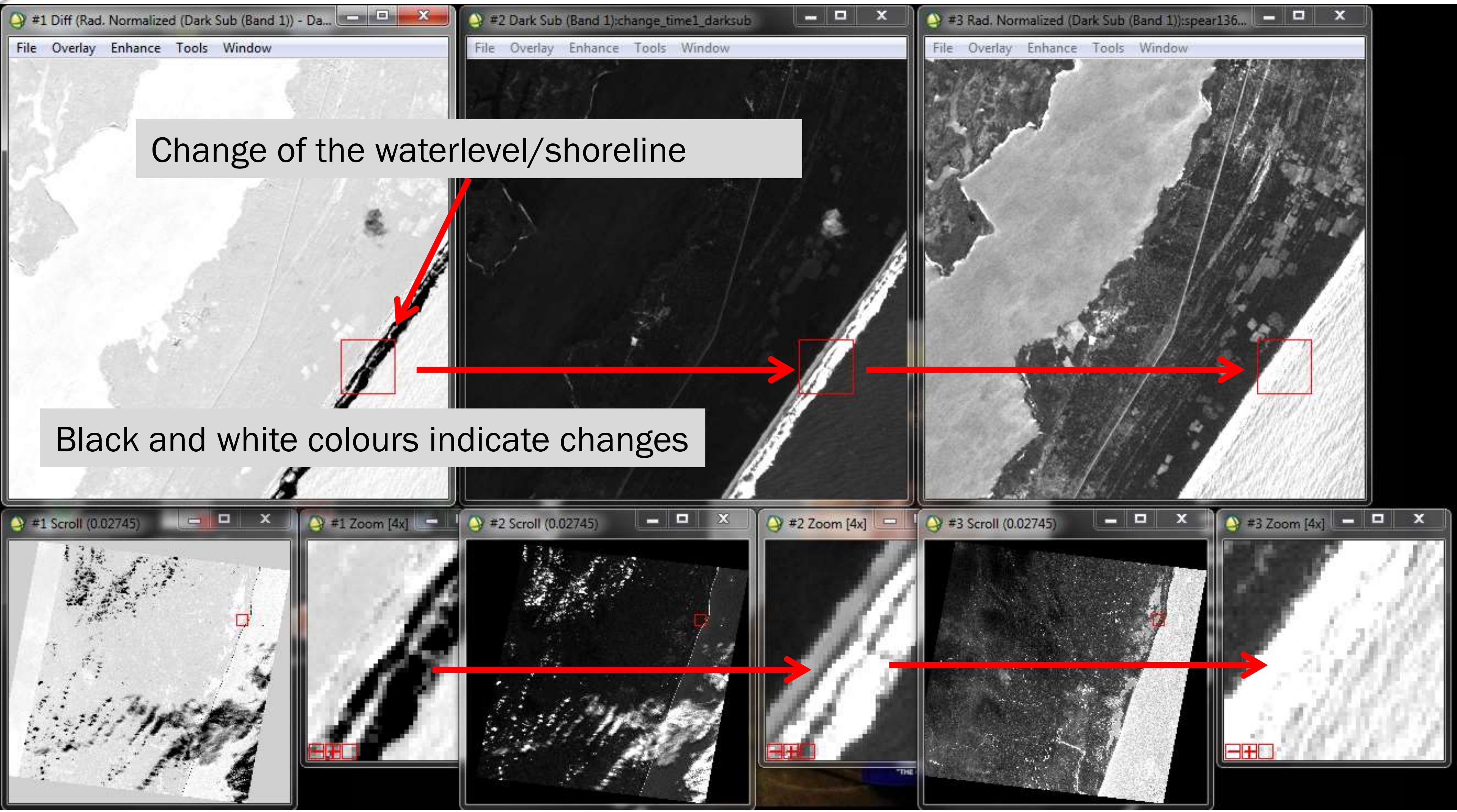


Image Transform (PCA)



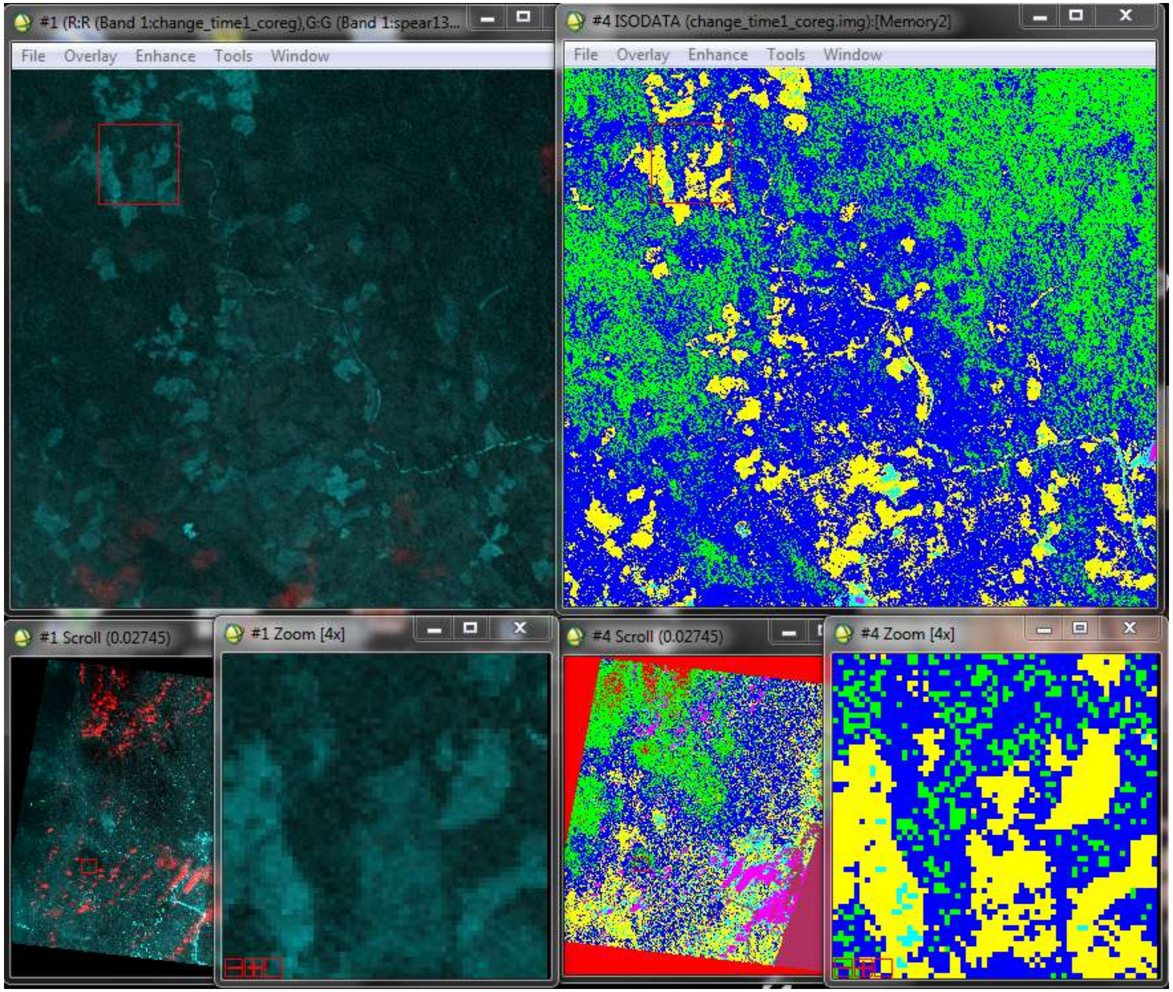
SPEAR Change Detection tool

Subtractive



Classification of Change Layer to identify Changes

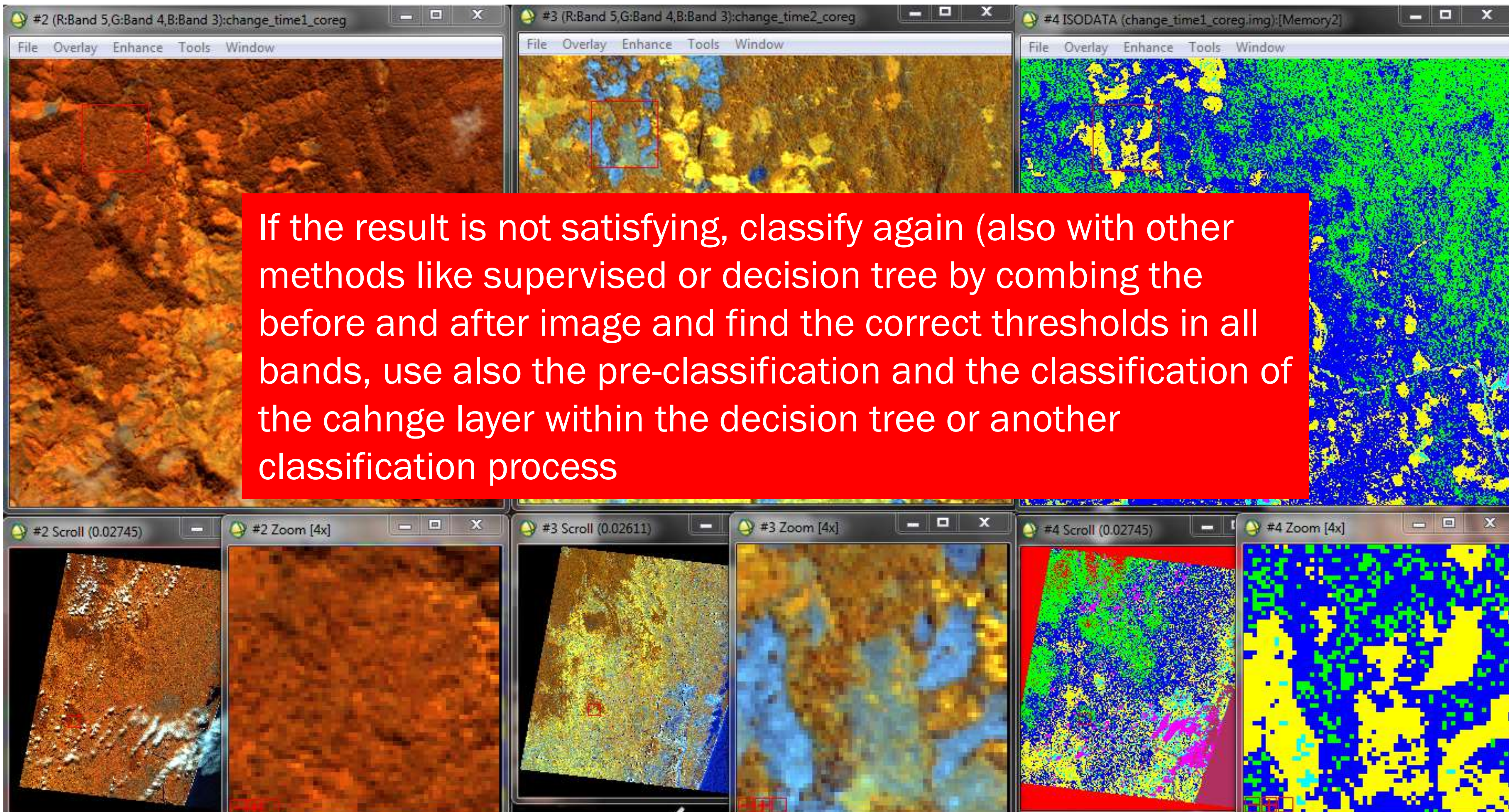
- ISODATA classification



Change Detection Post Processing

Classification of Change Layer to identify Changes

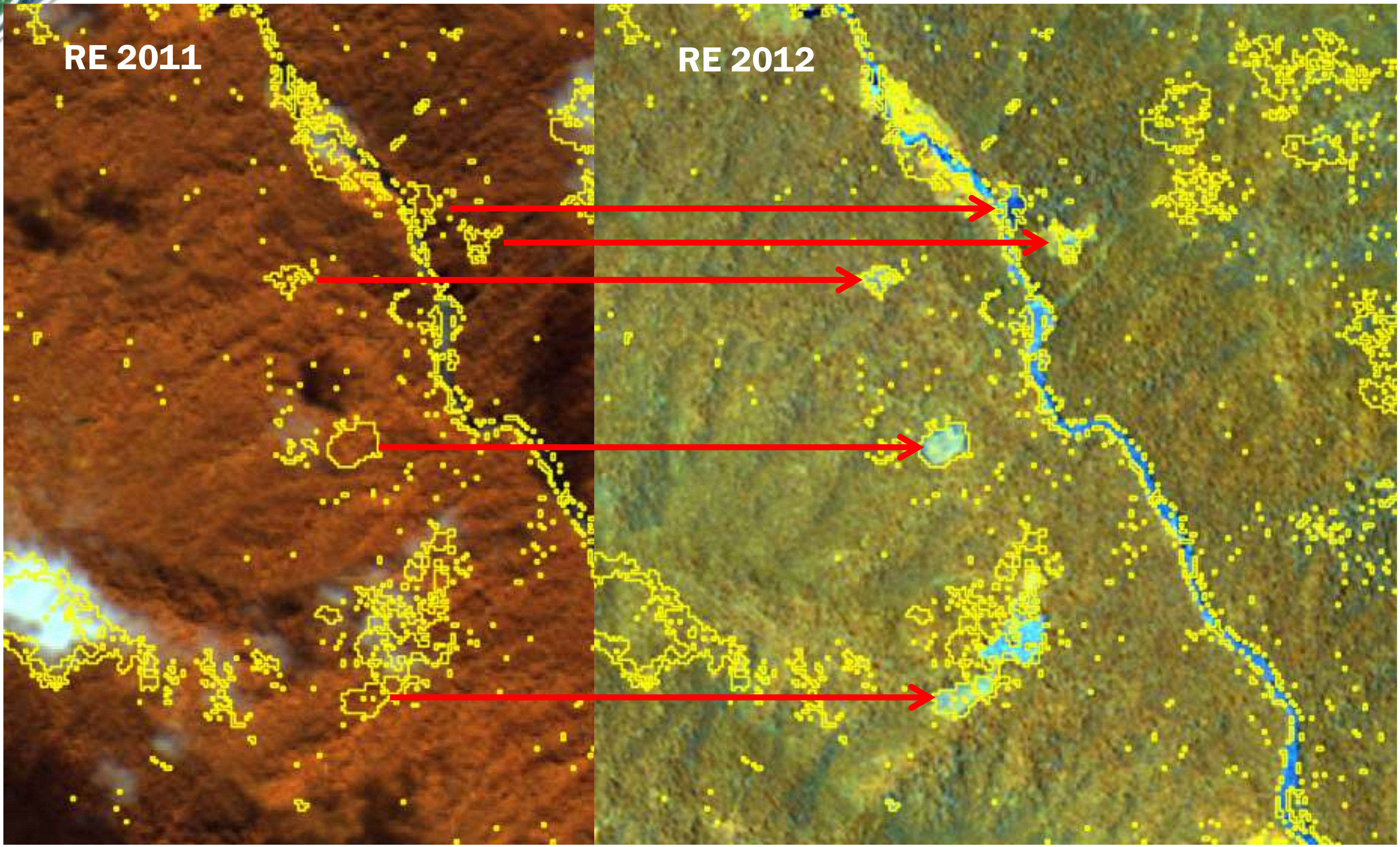
- ISODATA classification



If the result is not satisfying, classify again (also with other methods like supervised or decision tree by combing the before and after image and find the correct thresholds in all bands, use also the pre-classification and the classification of the cahnge layer within the decision tree or another classification process

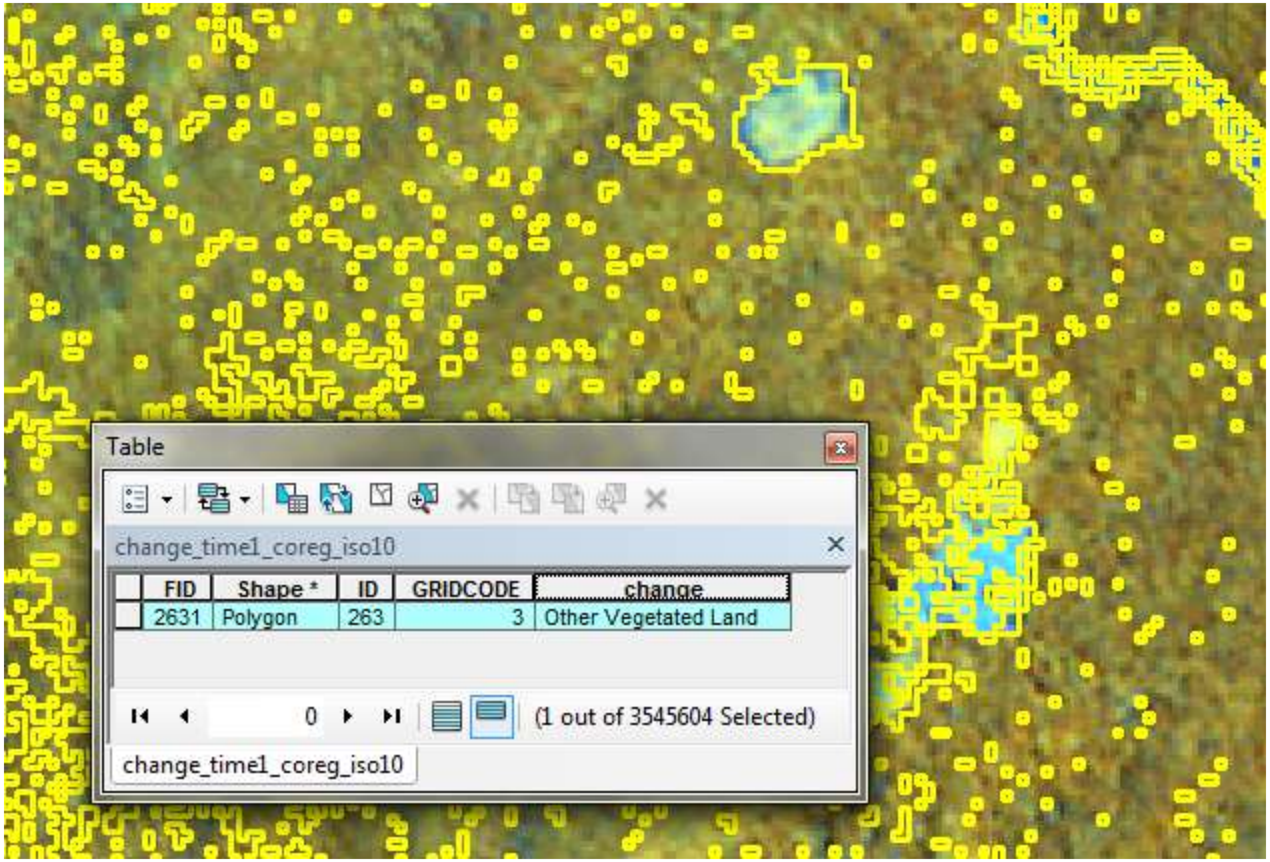
Change Detection Post Processing

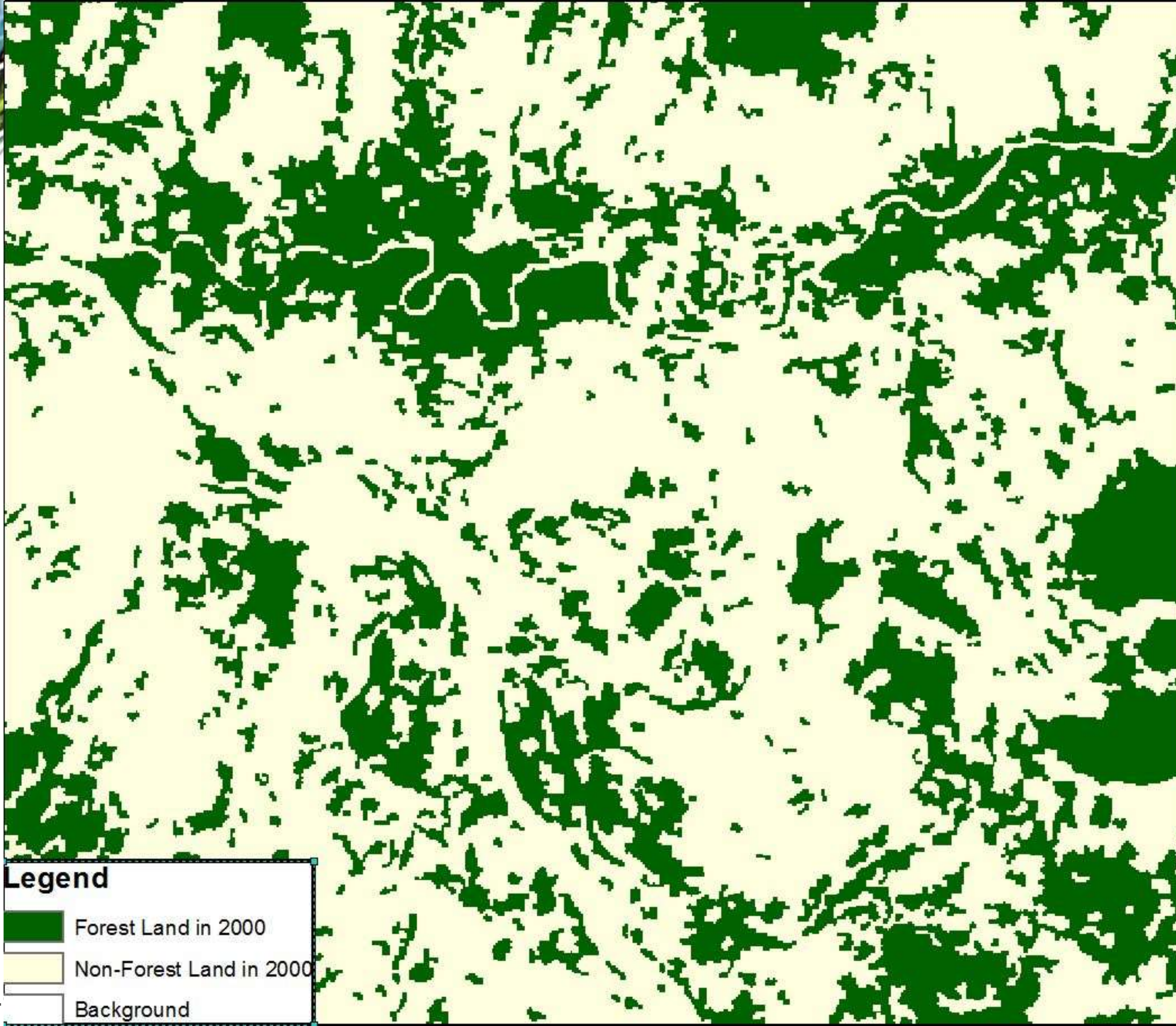
Manual Interpretation



Manual Interpretation

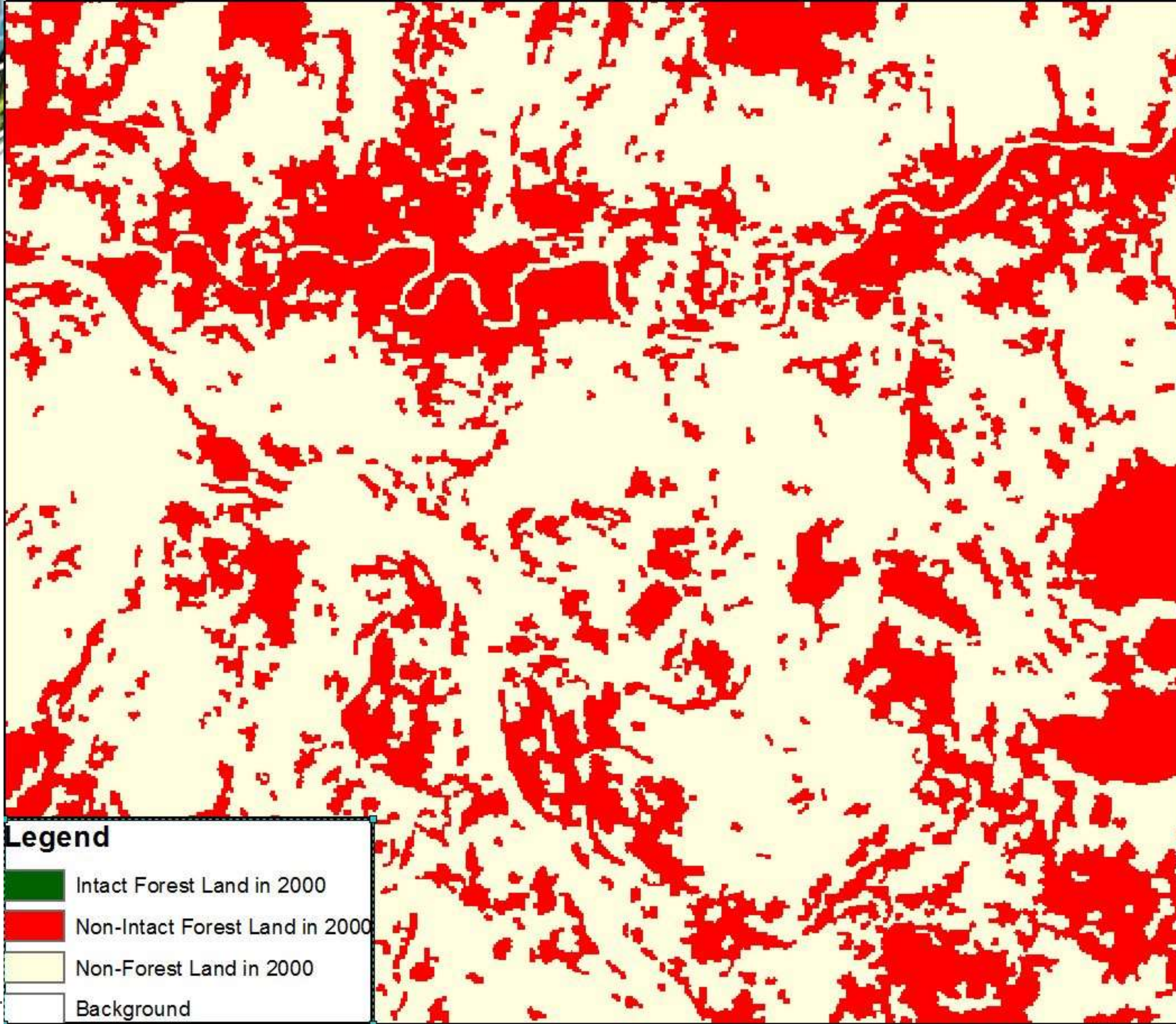
- Add a attribut to indicate the new class of 2012
- Select all change polygons adn intersect with the old classification

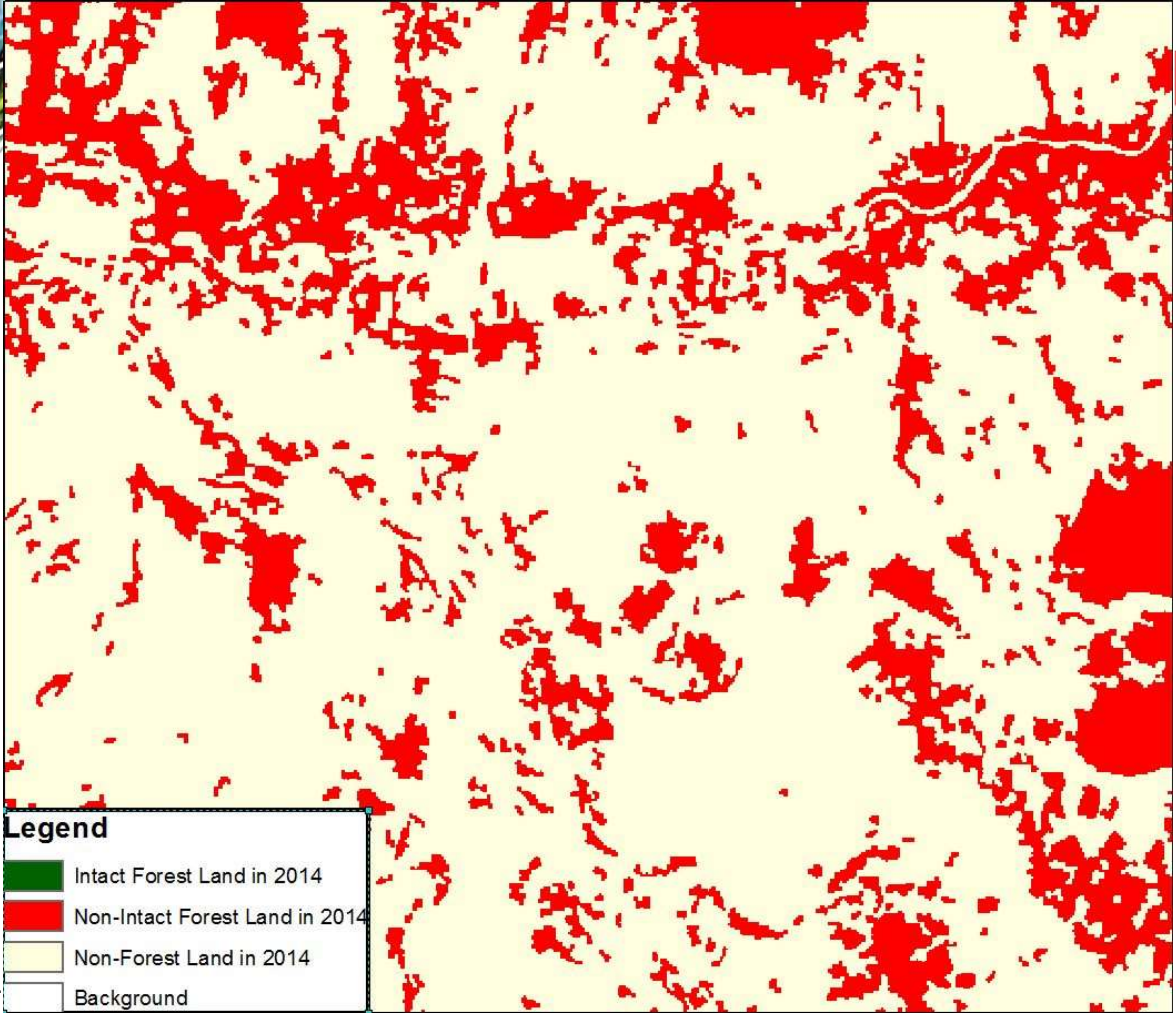


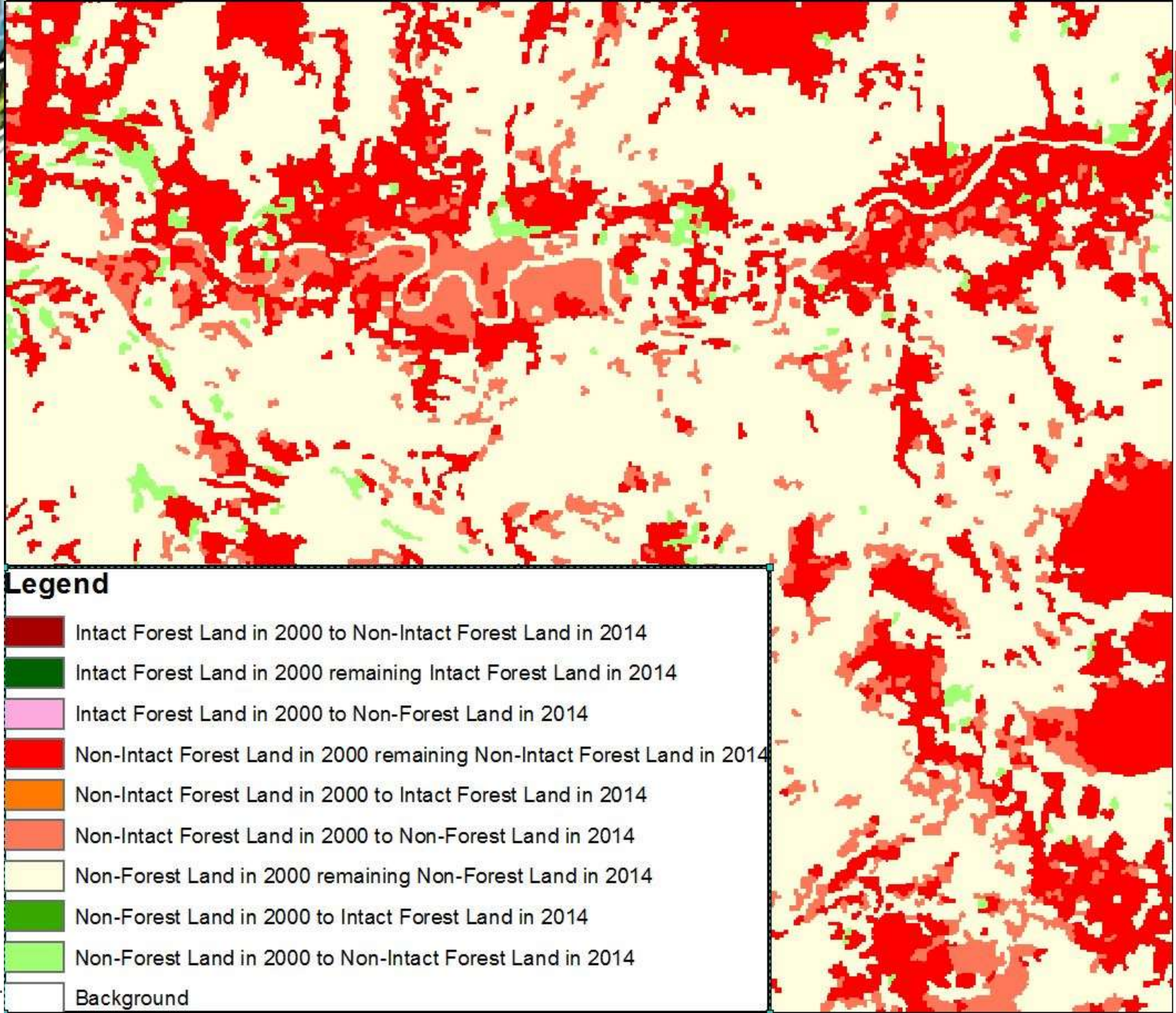

Legend
Forest Land in 2000
Non-Forest Land in 2000
Background


Legend
Forest Land in 2014
Non-Forest Land in 2014
Background


Legend
Forest Land in 2000 remaining Forest Land in 2014
Non-Forest Land in 2000 remaining Non-Forest Land in 2014
Non-Forest Land in 2000 to Forest Land in 2014
Forest Land in 2000 to Cropland in 2014
Forest Land in 2000 to Wetland in 2014
Forest Land in 2000 to Grassland in 2014
Forest Land in 2000 to Settlement in 2014
Forest Land in 2000 to Other Land Use in 2014
Background


Legend
Intact Forest Land in 2000
Non-Intact Forest Land in 2000
Non-Forest Land in 2000
Background


Legend
Intact Forest Land in 2014
Non-Intact Forest Land in 2014
Non-Forest Land in 2014
Background


Legend
Intact Forest Land in 2000 to Non-Intact Forest Land in 2014
Intact Forest Land in 2000 remaining Intact Forest Land in 2014
Intact Forest Land in 2000 to Non-Forest Land in 2014
Non-Intact Forest Land in 2000 remaining Non-Intact Forest Land in 2014
Non-Intact Forest Land in 2000 to Intact Forest Land in 2014
Non-Intact Forest Land in 2000 to Non-Forest Land in 2014
Non-Forest Land in 2000 remaining Non-Forest Land in 2014
Non-Forest Land in 2000 to Intact Forest Land in 2014
Non-Forest Land in 2000 to Non-Intact Forest Land in 2014
Background