Monitoring Gradual Ecosystem Changes using 30+ Years of Landsat Observations

Landsat Science Team Meeting

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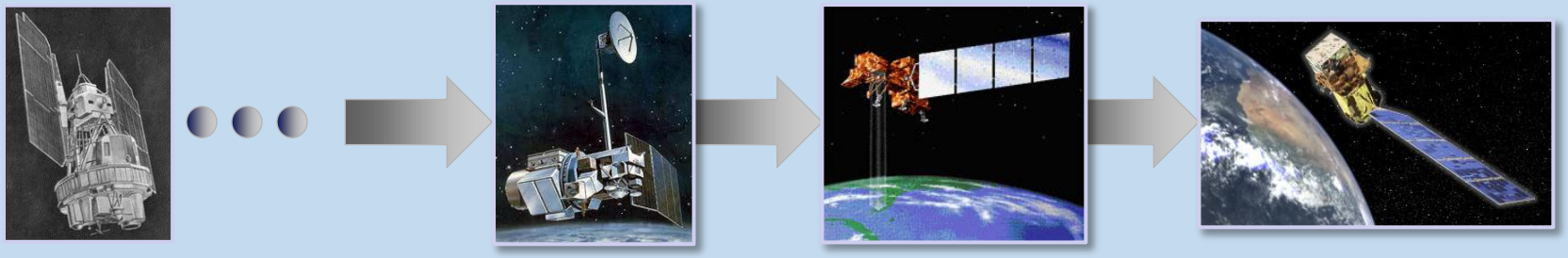
Gradual Change

What is it?

- The types of changes that result from gradual processes
  - Vegetation growth and succession
  - Damage by insects and disease
  - Vegetation decline due to prolonged drought or pollution
- These changes generally occur over several years to decades to longer



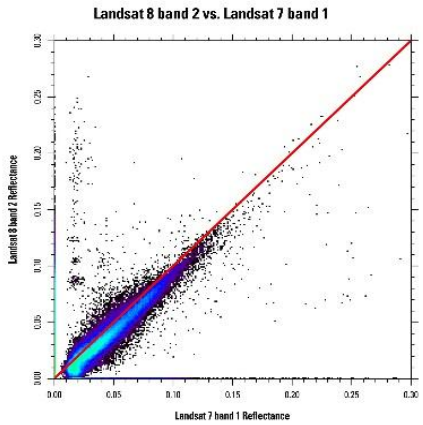
Landsat archive enables us to assess gradual changes (1982-present if we limit ourselves to TM/ETM+/OLI; 1972-present if we include MSS)

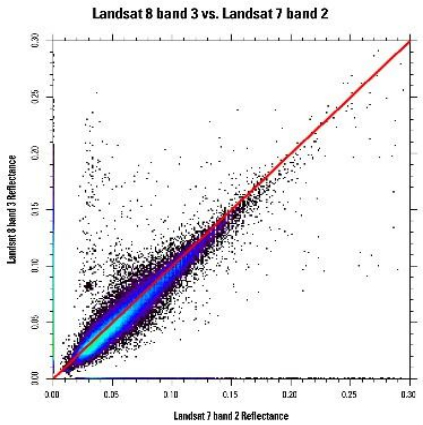
Why should we care about gradual landscape changes?

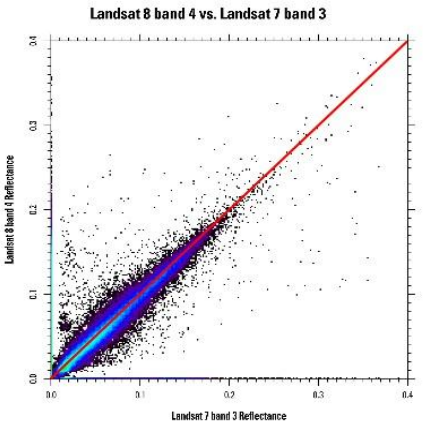
- Gradual changes are pervasive. Depending on the area, the combined ecological impact of gradual changes can outweigh the impact of land cover conversion events.

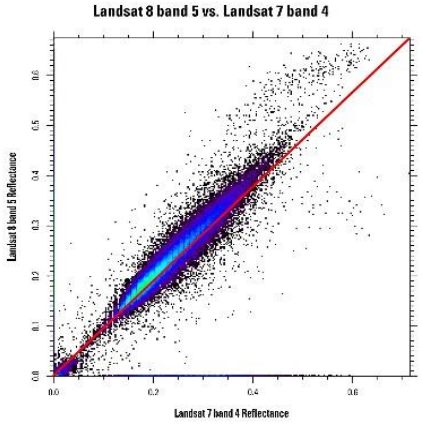
- Plants are very good “barometers” of climate change. Such changes are expected to be gradual.

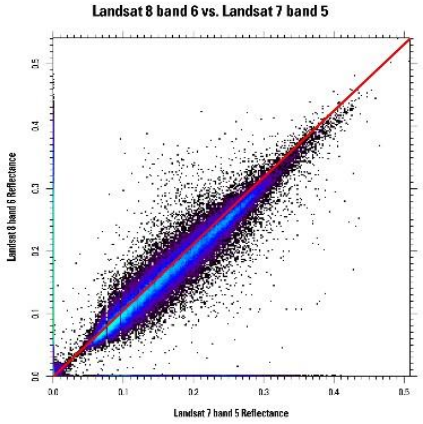
- Do we want to know where carbon sequestration is occurring?
  - Look for areas of sustained (e.g. over several decades) vegetation growth!

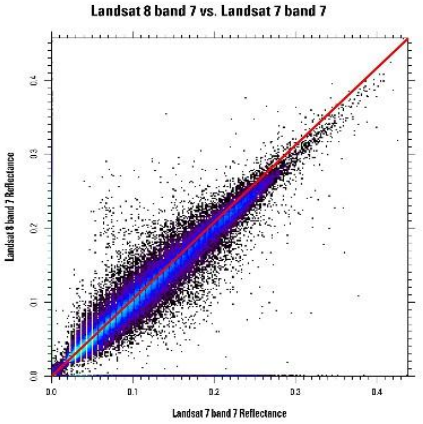




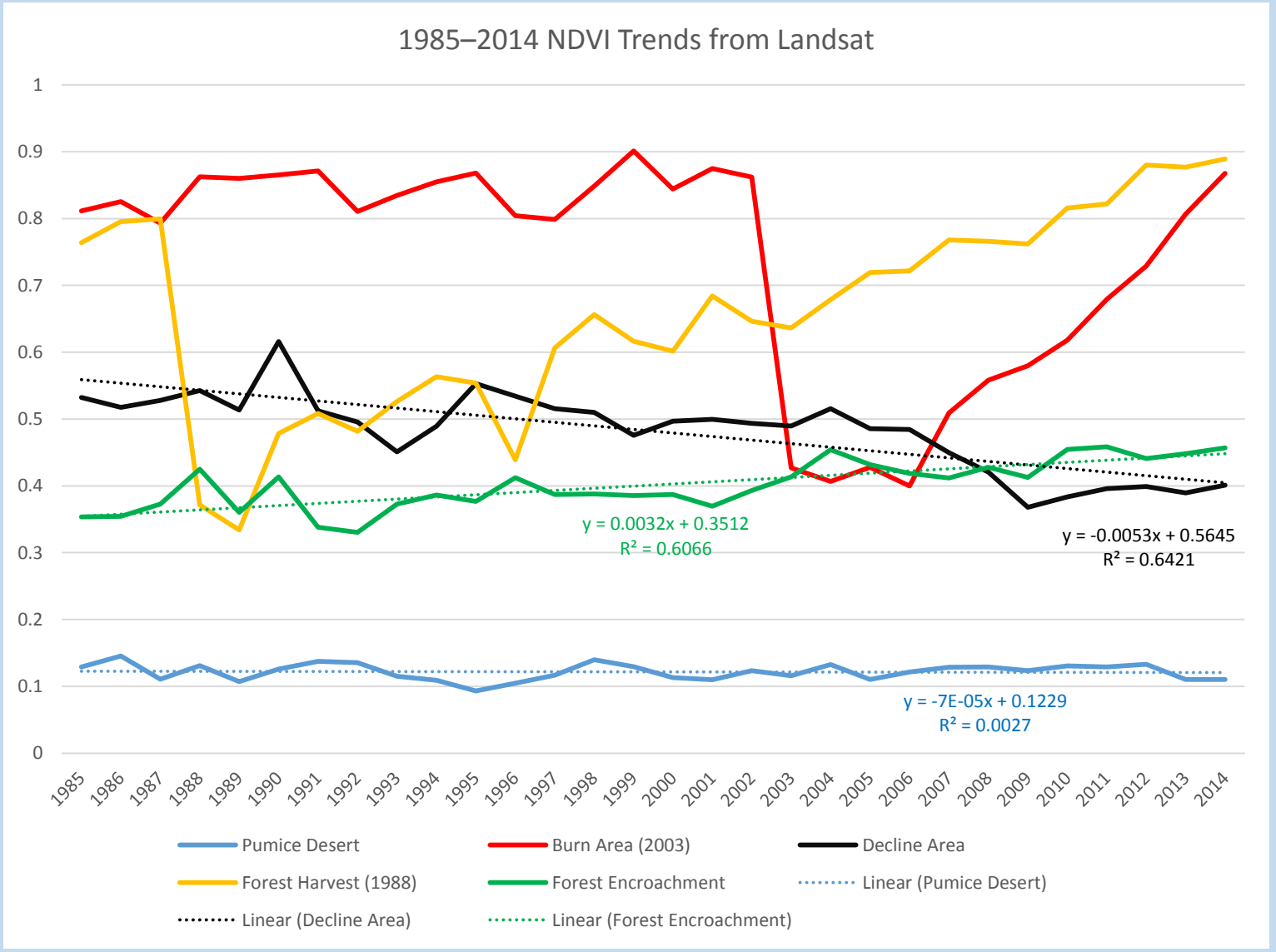




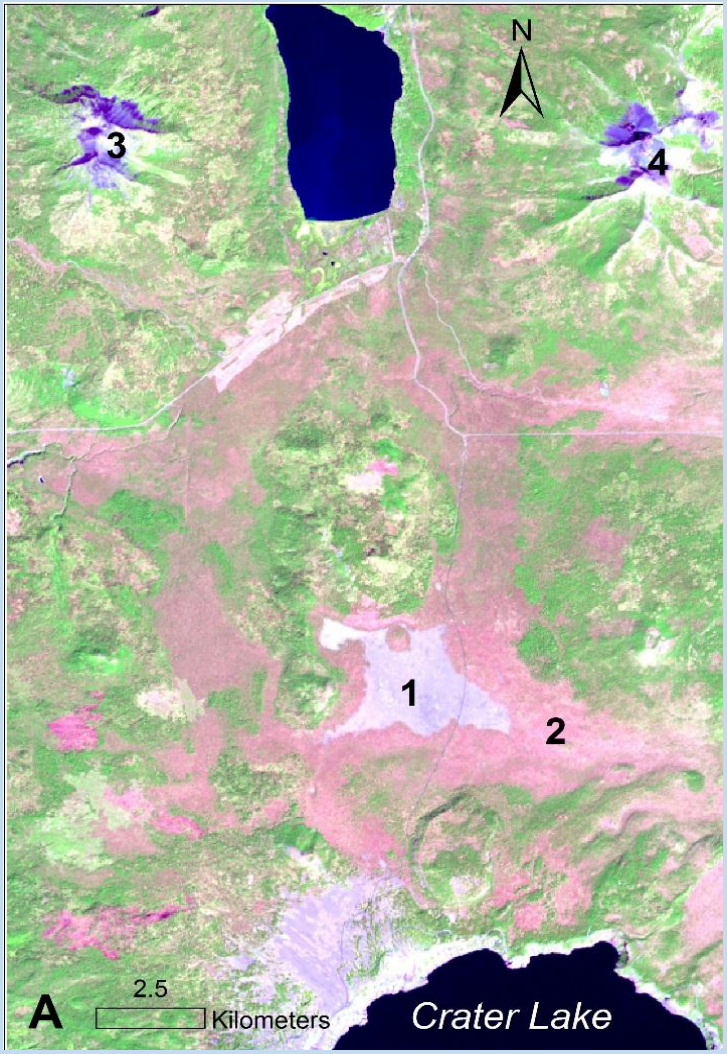




Pixel by pixel comparisons of Landsat 7 vs Landsat 8 atmospherically corrected data (July 20, 2013 L7 vs July 28, 2013 L8; path 45, row 30)


1985–2014 NDVI Trends from Landsat
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
y = 0.0032x + 0.3512
R² = 0.6066
y = -0.0053x + 0.5645
R² = 0.6421
y = -7E-05x + 0.1229
R² = 0.0027
Pumice Desert
Burn Area (2003)
Decline Area
Forest Harvest (1988)
Forest Encroachment
Linear (Pumice Desert)
Linear (Decline Area)
Linear (Forest Encroachment)

Portion of Crater Lake, Oregon scene

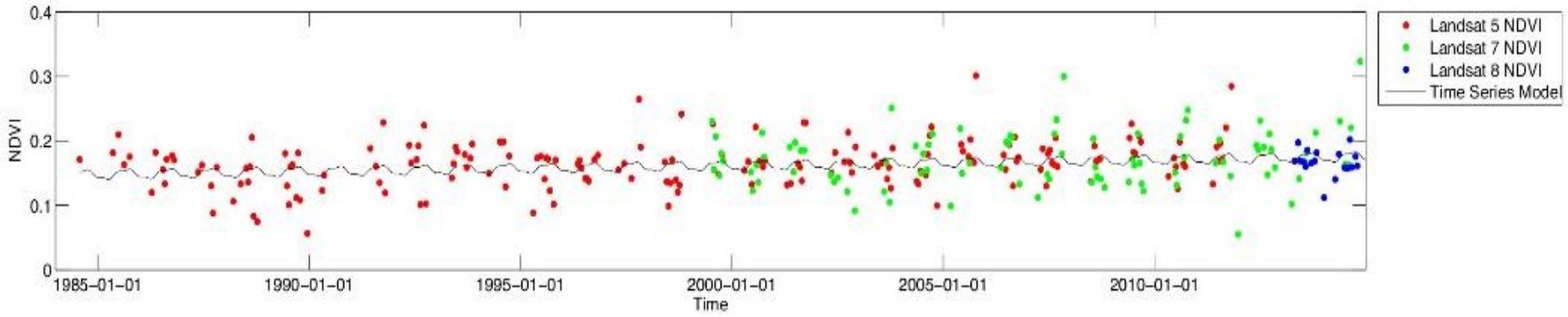


OLI image (Sept 1, 2013)

NDVI vs Time Slope Image (30 year trend)

1=Pumice Desert (no trend), 2=Zone of decline, 3=Mt. Bailey, 4=Mt. Thielsen

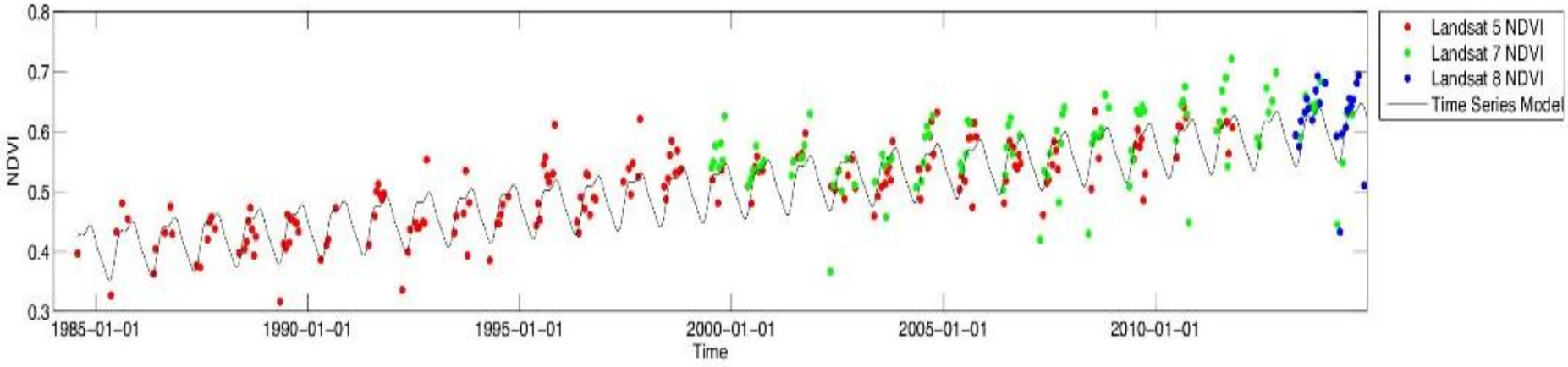
Landsat 5, 7 and 8 NDVI data (1985-2014) for Pumice Desert



Red = Landsat 5 TM
Green = Landsat 7 ETM+
Blue = Landsat 8 OLI

Note: No obvious trend is obvious
(nor is there one that is to be expected)

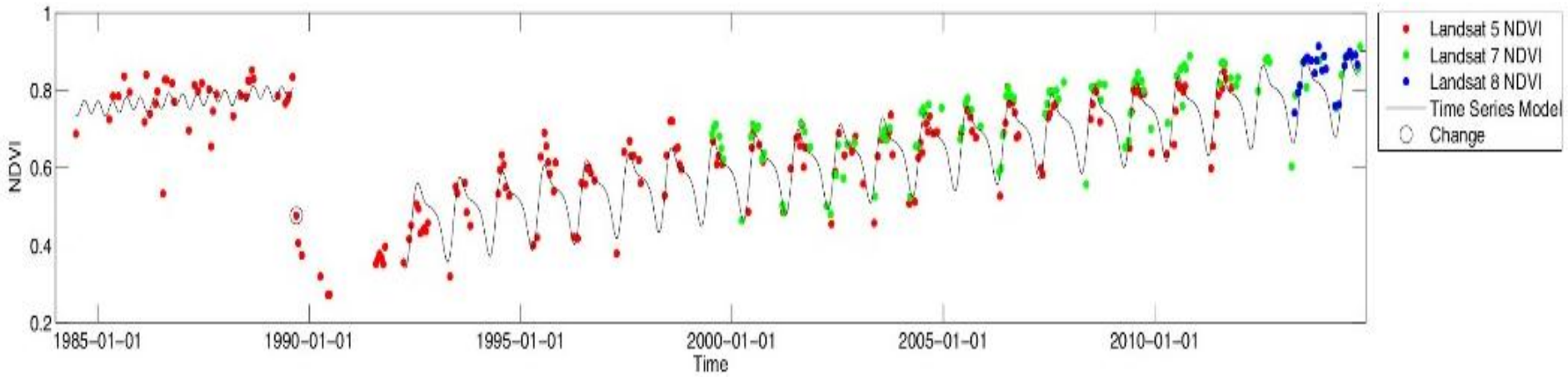
Landsat 5, 7 and 8 NDVI data (1985-2014) for Forest-Desert Transition Zone



Red = Landsat 5 TM
Green = Landsat 7 ETM+
Blue = Landsat 8 OLI

Note: Good gradual upward trend in NDVI;
OLI points fit well onto the L7 and L5 trend line

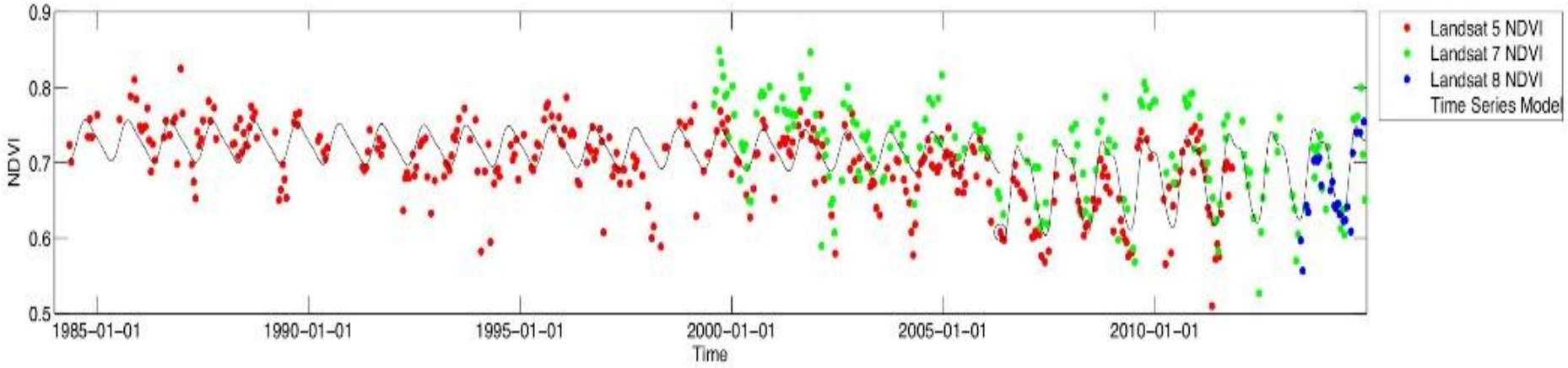
Landsat 5, 7 and 8 NDVI data (1985-2014) for area logged in 1989



Red = Landsat 5 TM
Green = Landsat 7 ETM+
Blue = Landsat 8 OLI

Note: Good trend from 1991 to present
(OLI points fit well with L5 and L7 trend)

Landsat 5, 7 and 8 NDVI data (1985-2014) for an area in SW US experiencing drought



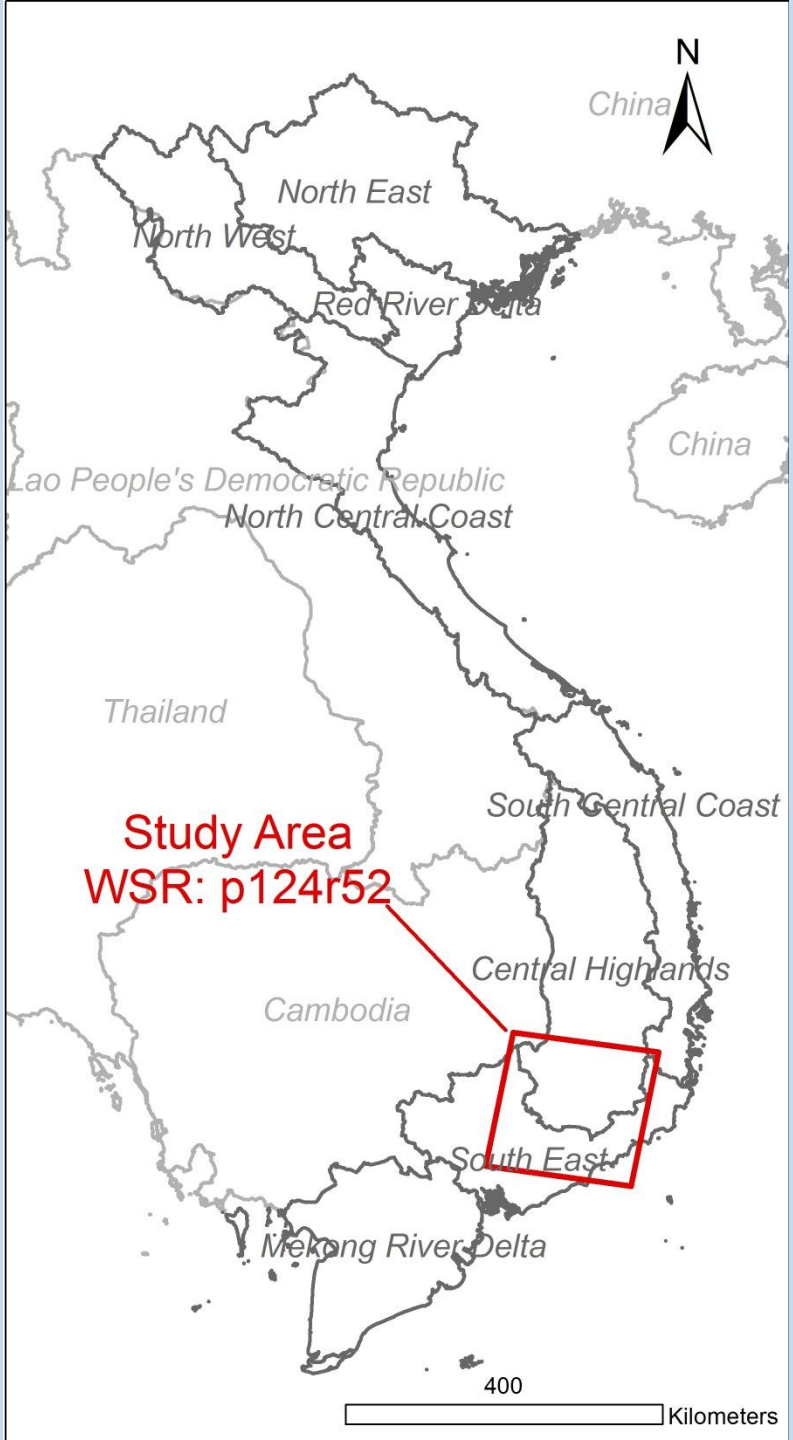
Red = Landsat 5 TM
Green = Landsat 7 ETM+
Blue = Landsat 8 OLI

Note: Increased variability as drought progresses

Can these approaches work in places that have limited Landsat data?

- About one year ago, with funding from SilvaCarbon, we began a project using Landsat time series to assess forest degradation in Lam Dong Province, Vietnam
- Our Vietnamese counterparts are Drs. Khoa van Phung and Do Xuan Lan
  - Will be visiting us at USGS EROS during late July-August for collaborative activities
- Conducted a site visit during summer 2014 to familiarize ourselves with study area

Project Study Area



Vietnam Pictures from Field Excursion in 2014

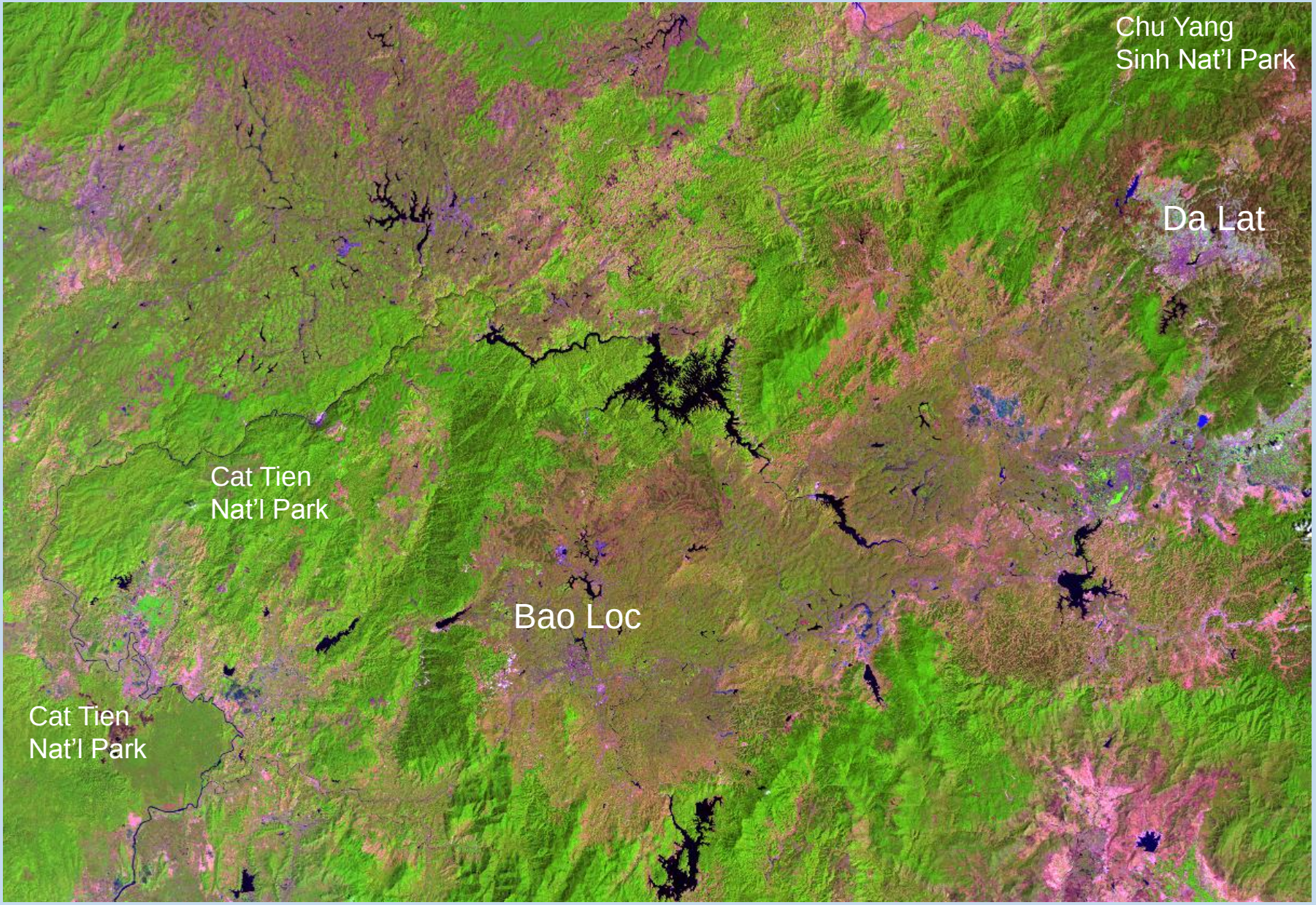
Mature Forest

Coffee Plantation

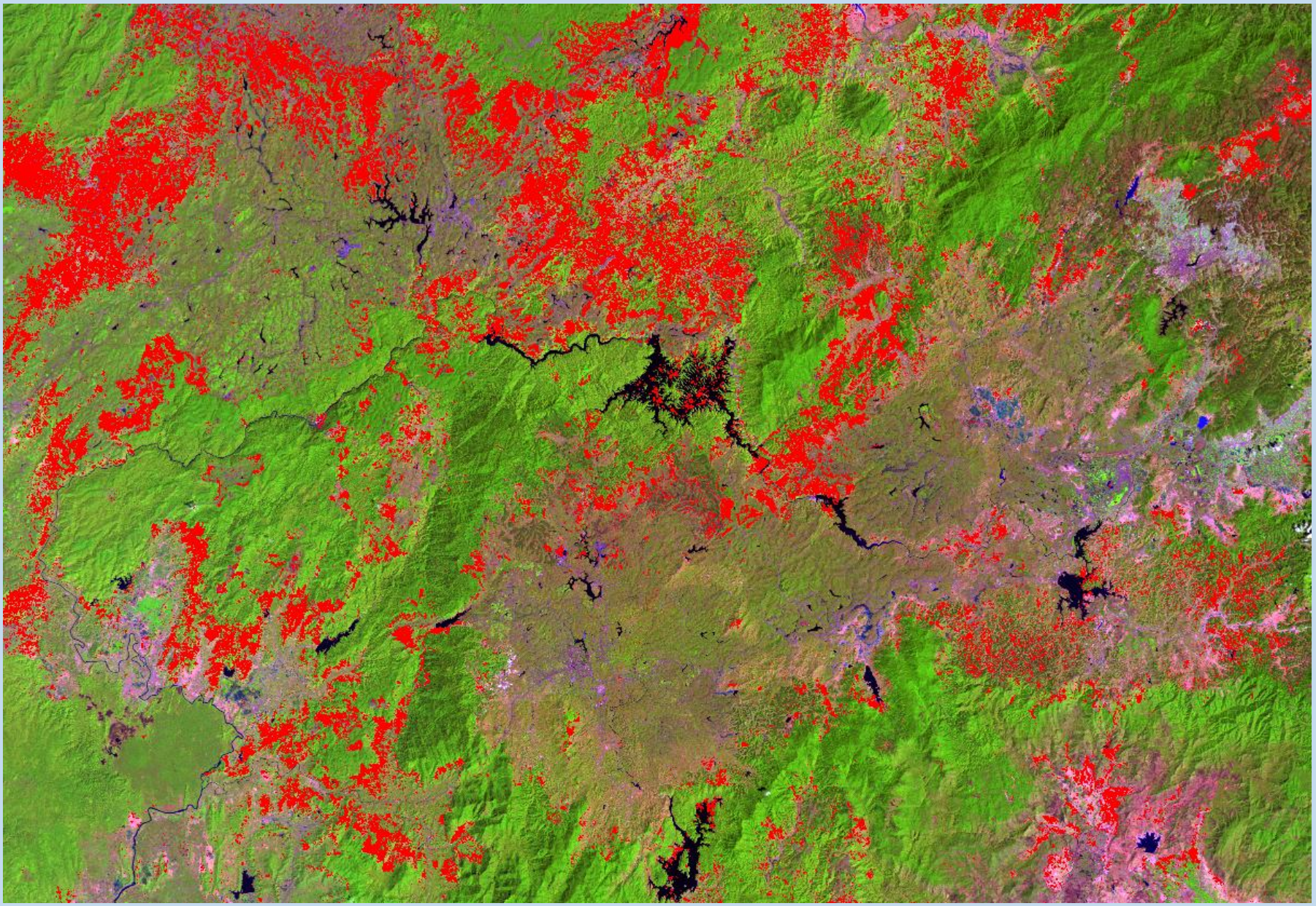
Selective Harvest/Conversion

Plantation Forest

Landsat 8 image including a major portion of Lam Dong Province

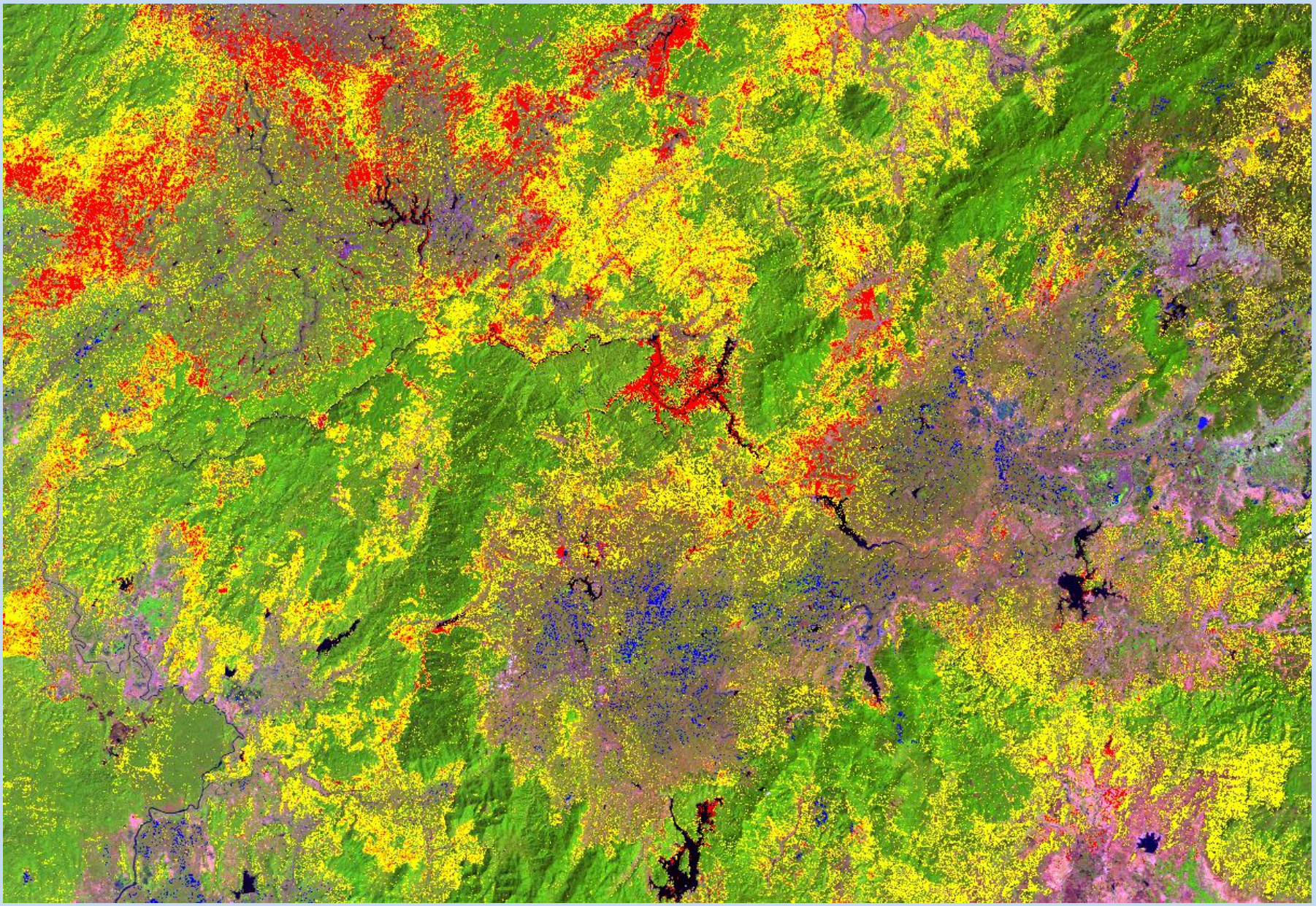


Forest loss according to Global Forest Change Data set (2000-2012)



Red represents areas of forest loss

Map showing forest change using NDVI trends data (1985 – 2014)

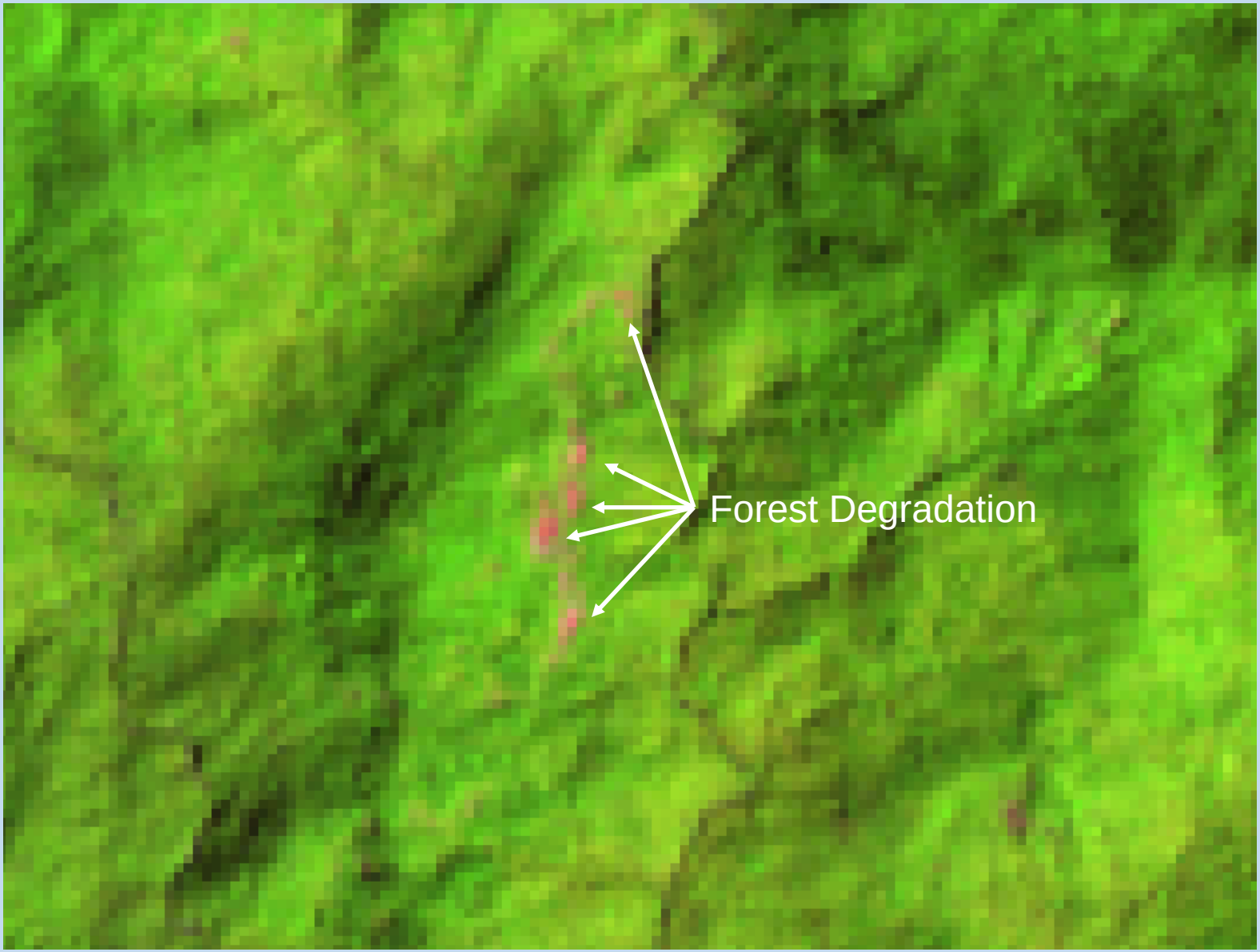


Red = Major change in greenness; Yellow = Moderate change in greenness; Blue = Increase in greenness

But can we detect subtle forest degradation using this approach? An example from Google earth using 2013 high resolution satellite data

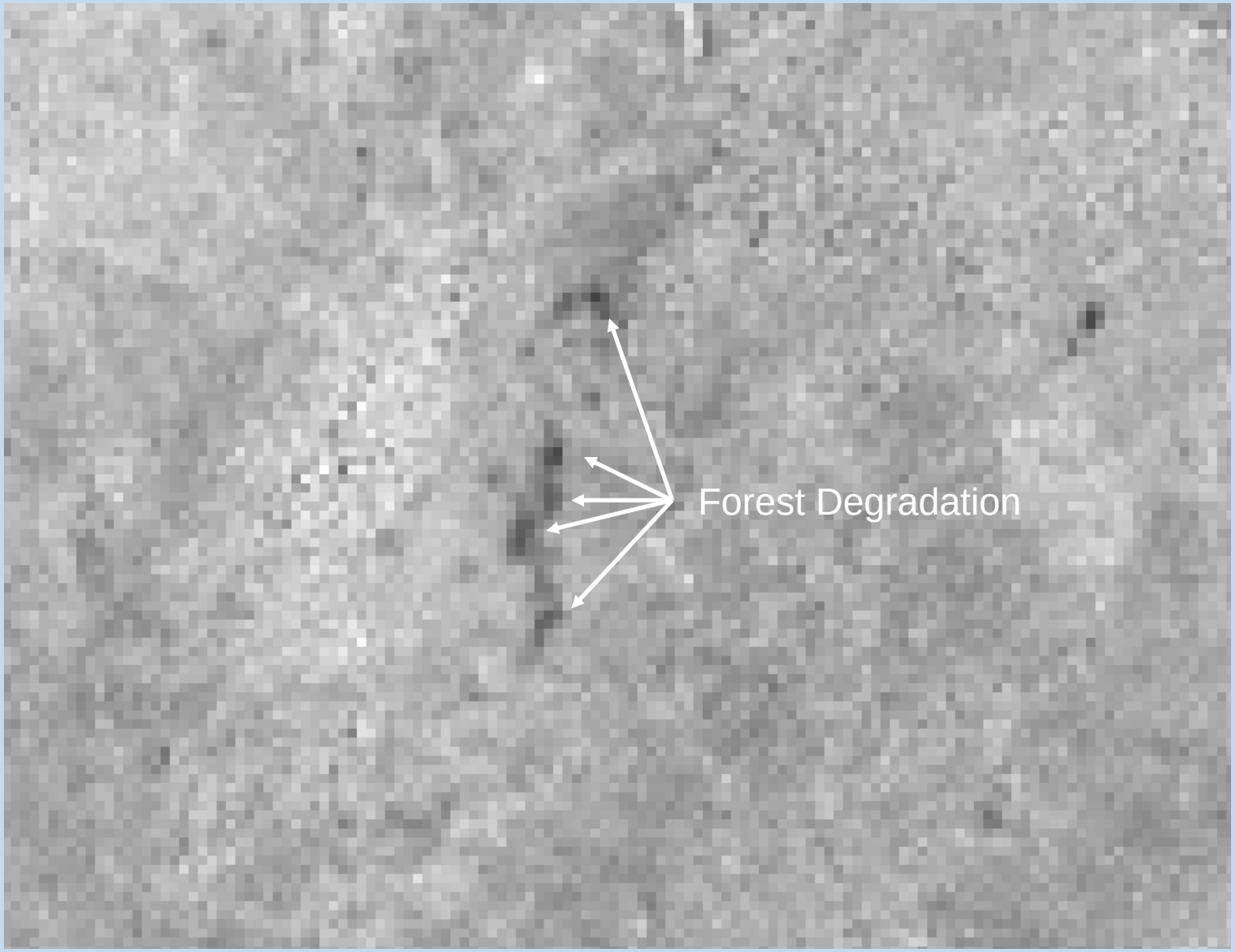
Location: Forest in Lam Dong scene

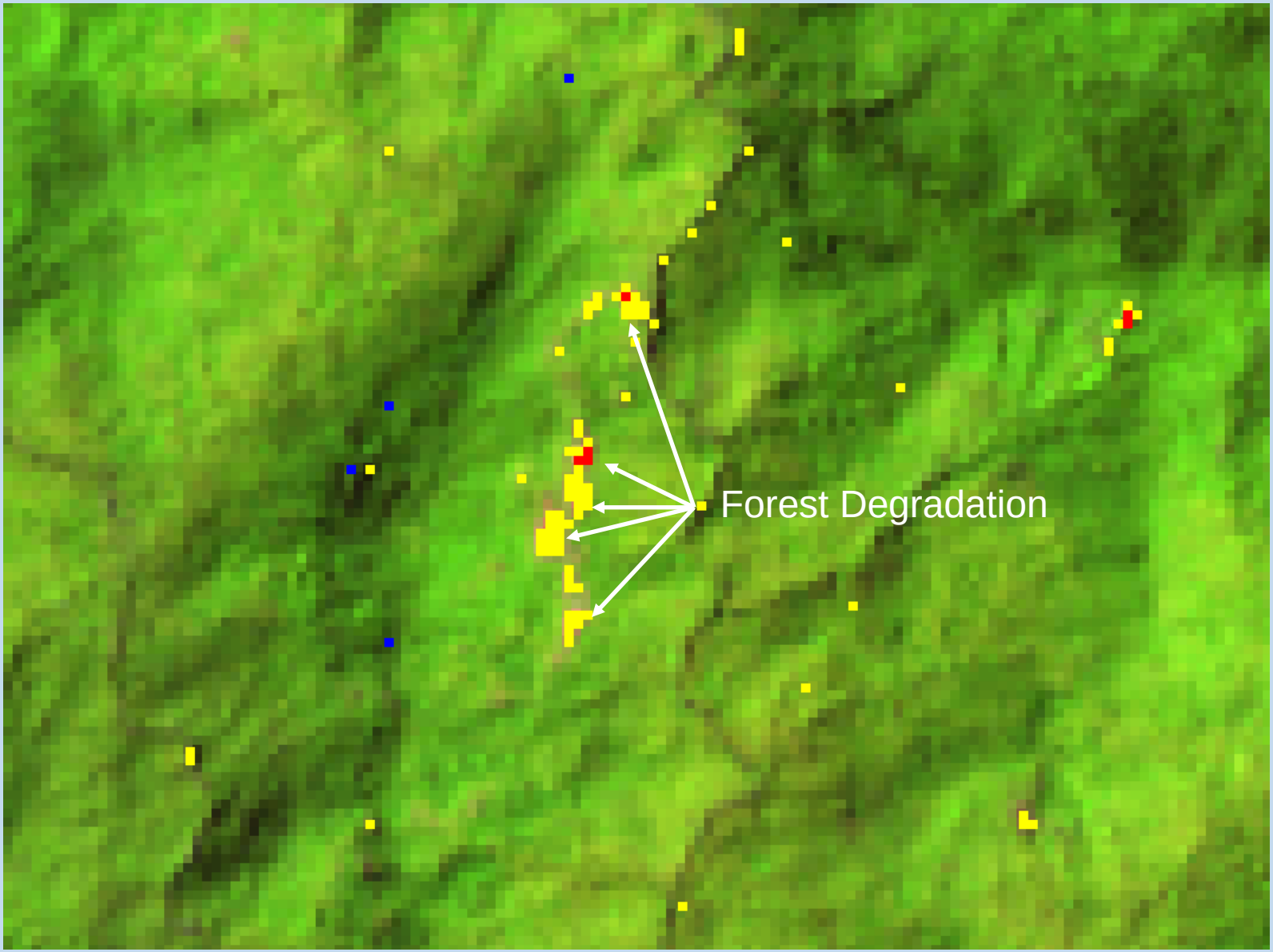
Same approximate area in Landsat 8 (2014) image



The problem with these areas is that they are generally difficult to classify

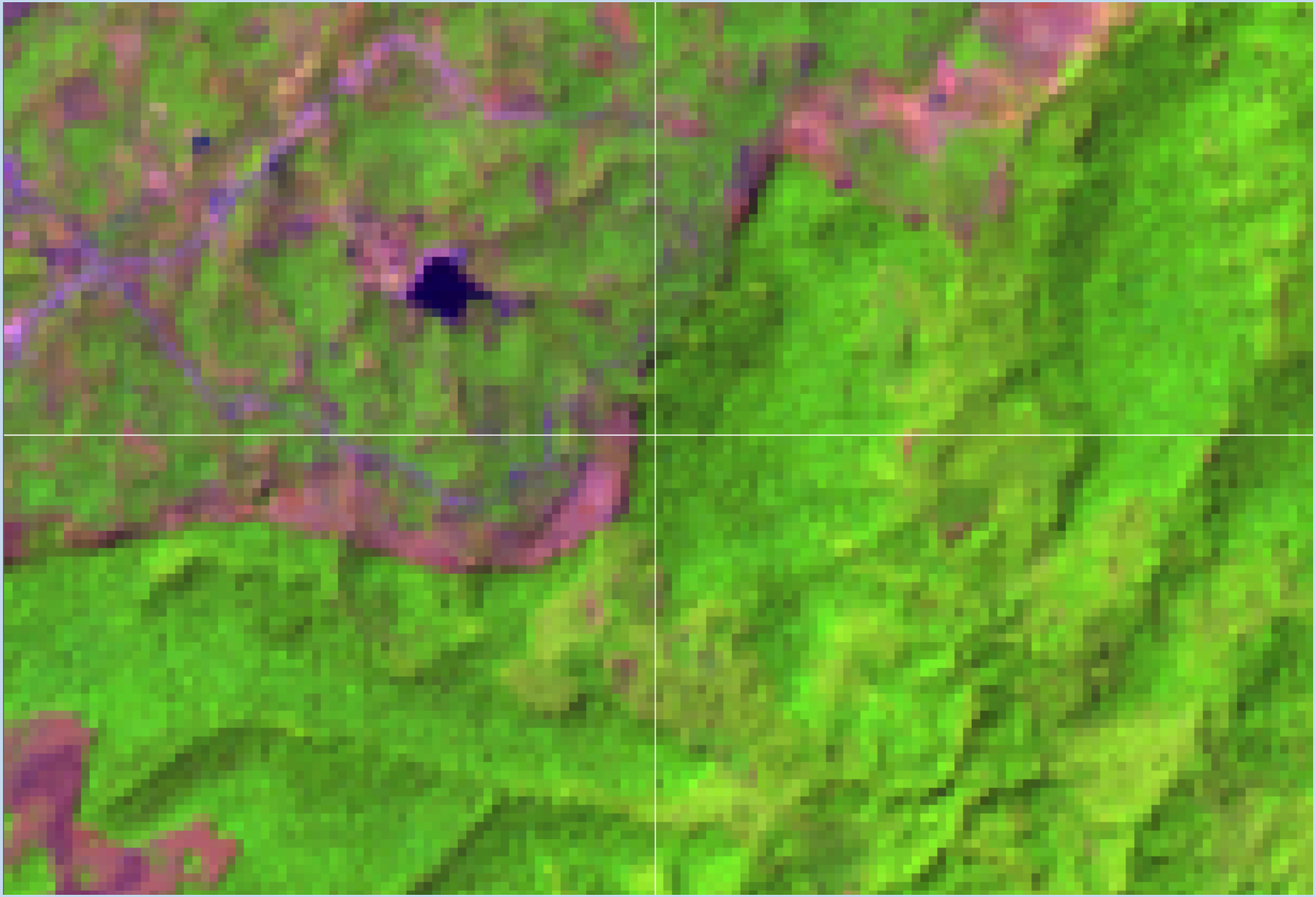
Trends image using 1985-2014 NBR data from Landsat



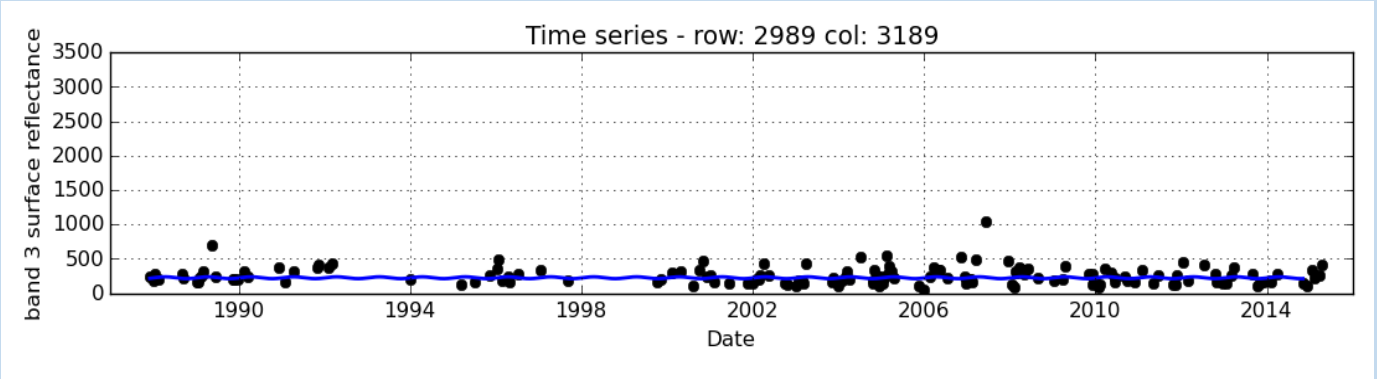


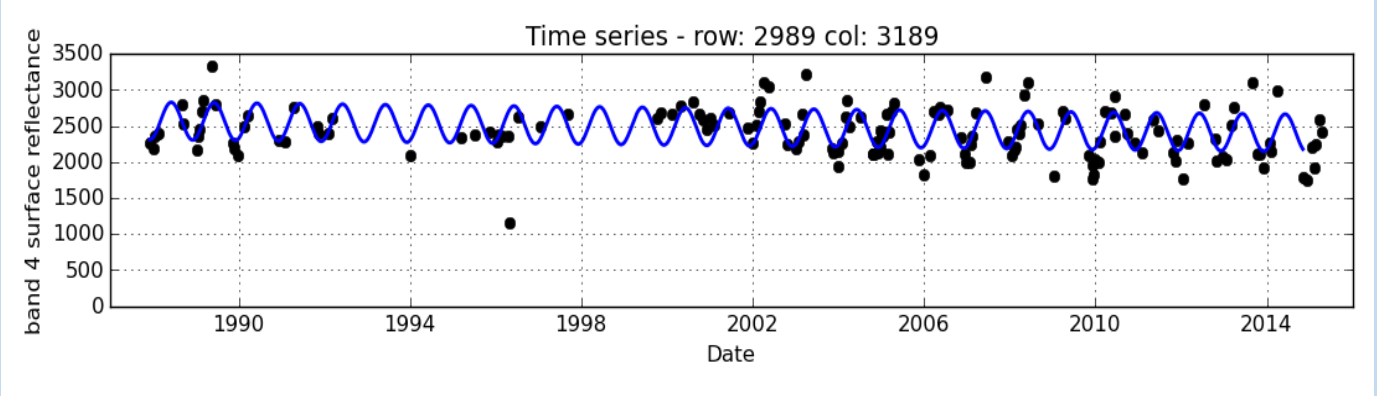
These areas do classify OK, but are easier to see in the imagery than to classify

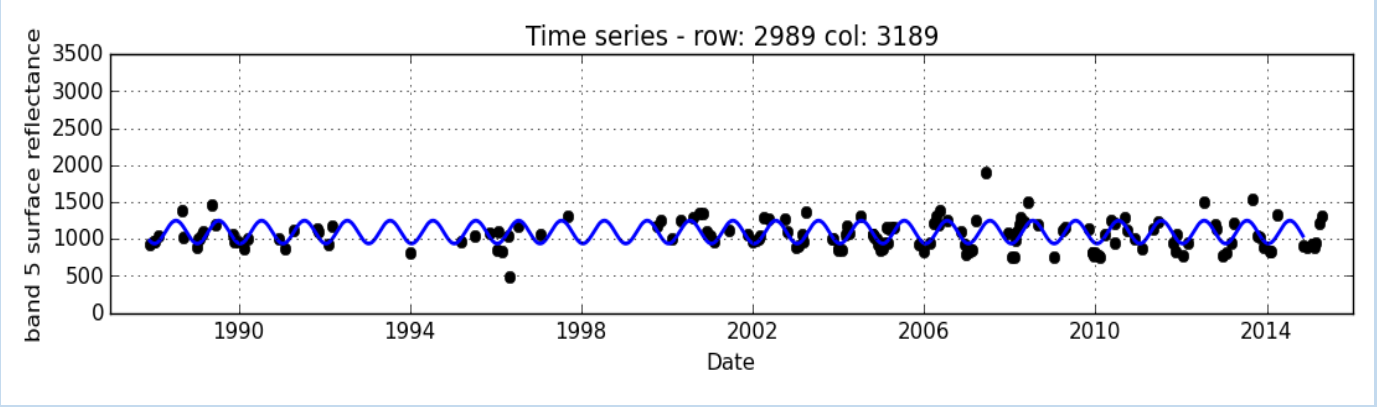
Let’s look at the CCDC profile of a single mature forest pixel from Vietnam (at cross-hair)



These CCDC plots were produced for a single mature forest pixel using all dates of clear observations for red, NIR, and SWIR 1 bands. No obvious changes across time.

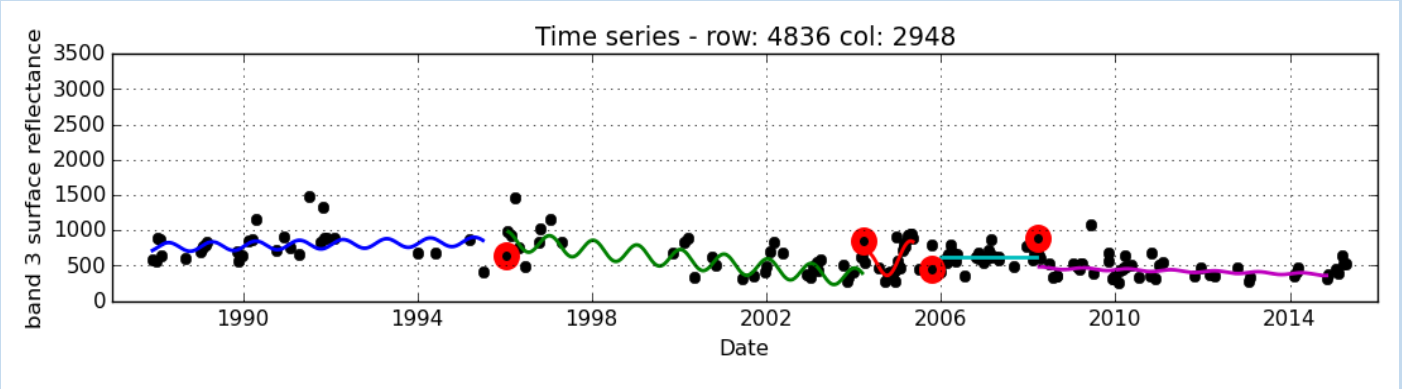


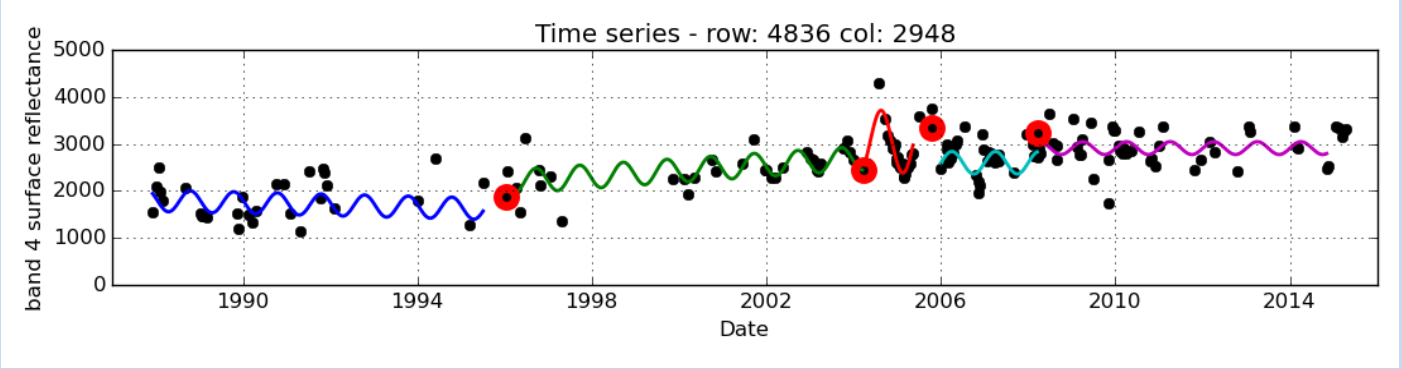


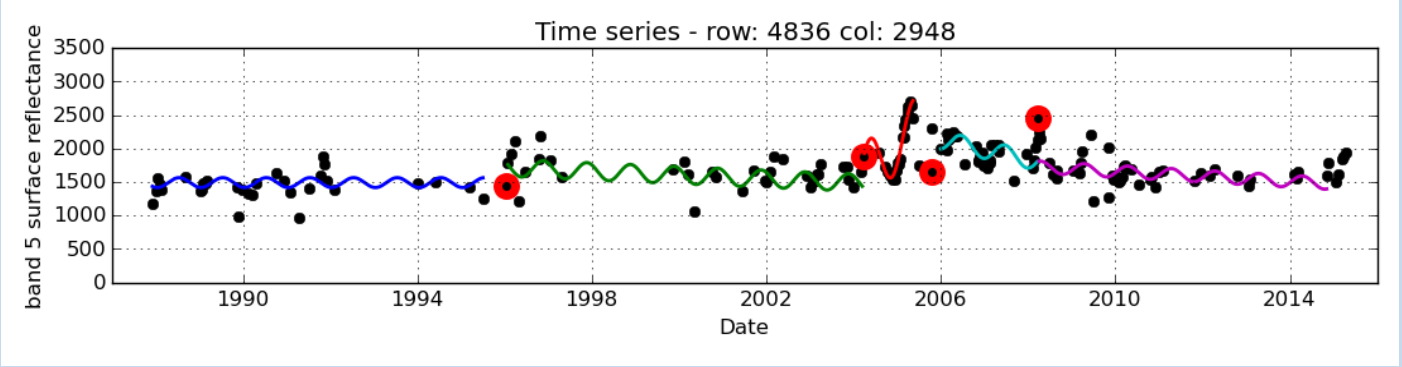


These CCDC plots were produced for a single plantation pixel using all dates of clear observations for red, NIR, and SWIR 1 bands. Lots of changes are apparent.

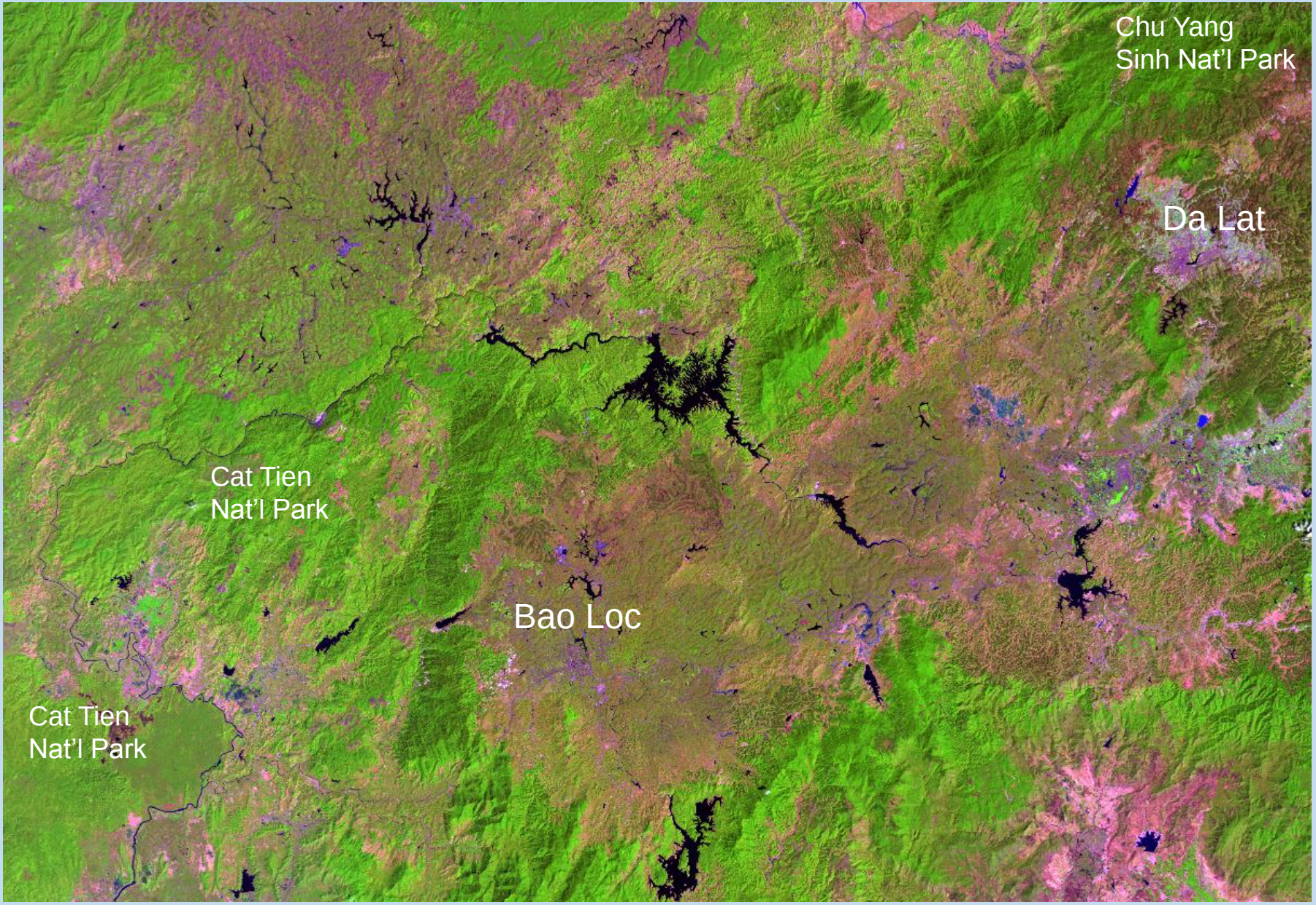
Using a single image, these plantations can be very difficult to classify. They should be easier to classify using time series data.



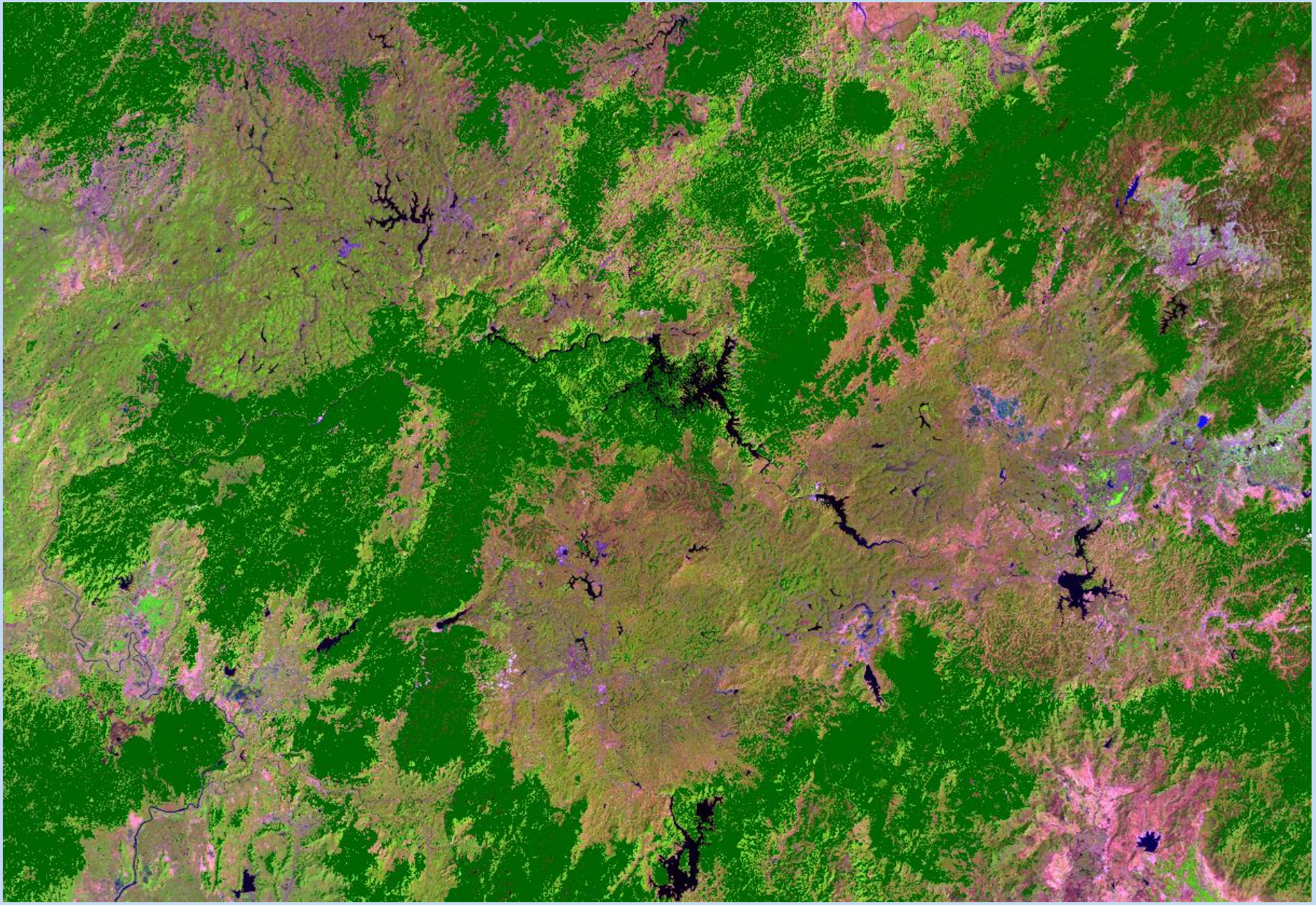




Once again, Landsat 8 image including a major portion of Lam Dong Province



Persistent forest using CCDC approach. Pixels with which match the “no change” forest condition, similar to the mature forest pixel earlier are dark green



Conclusions and Limitations

- Landsat time series data are powerful for providing gradual change information.
  - Some places (e.g. US) are very data rich, and trend analyses will be straightforward to conduct.
  - Ample numbers of Landsat data sets available for some countries such as Vietnam.
  - Data volume likely to be a problem in some places (e.g. much of Africa).
- There are a number of time series approaches that are appropriate for conducting change assessments.
  - Of them, CCDC is the most powerful
- We are able to detect reasonably subtle forest changes using time series data
  - Validation of subtle forest changes is a challenge
- Persistent forest cover may provide good information for assessing stability