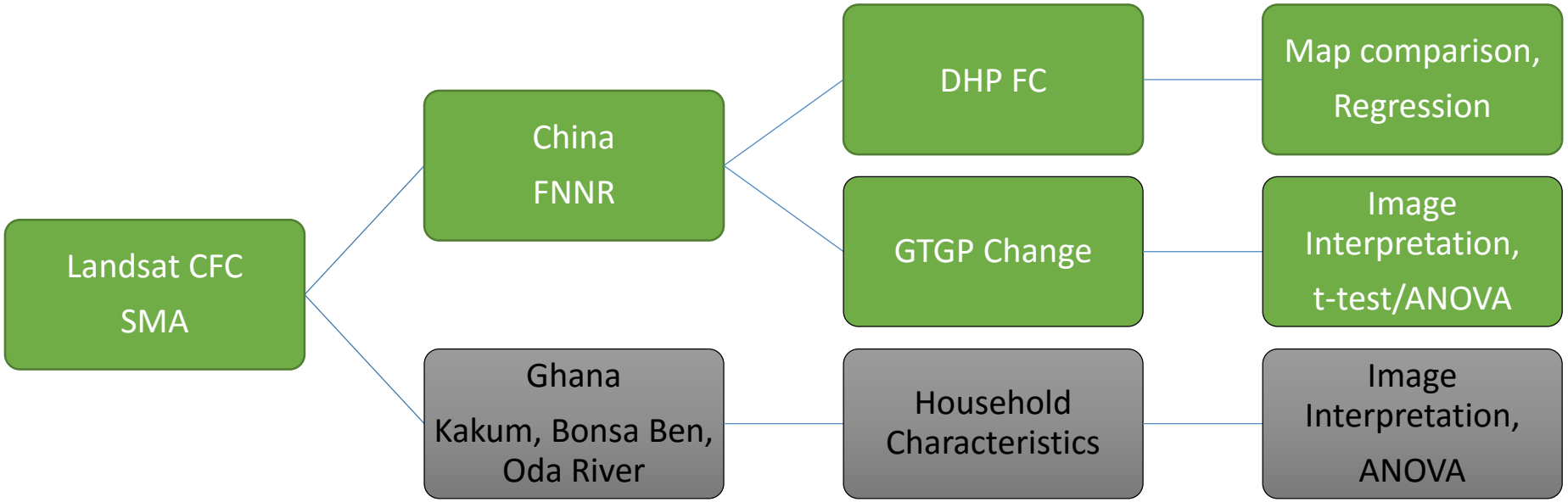
Quantifying Forest Cover in Fanjingshan National Nature Reserve Using Landsat Imagery

Yu Hsin Tsai, NSF-CNH Summit Sep 24, 2016

Objectives

- Develop a reliable approach to estimate forest fractional cover and monitor changes

- Link forest cover change to potential causes in selected forest reserves in FNNR and Ghana
  - Method application at different places
  - Fanjingshan National Nature Reserve in China
  - Kakum, Oda River, Bonsa Ben in Ghana


Landsat CFC
SMA
China
FNNR
Ghana
Kakum, Bonsa Ben, Oda River
DHP FC
GTGP Change
Household Characteristics
Map comparison, Regression
Image Interpretation, t-test/ANOVA
Image Interpretation, ANOVA

Landsat Satellite Images

Available Landsat TM and OLI* Images

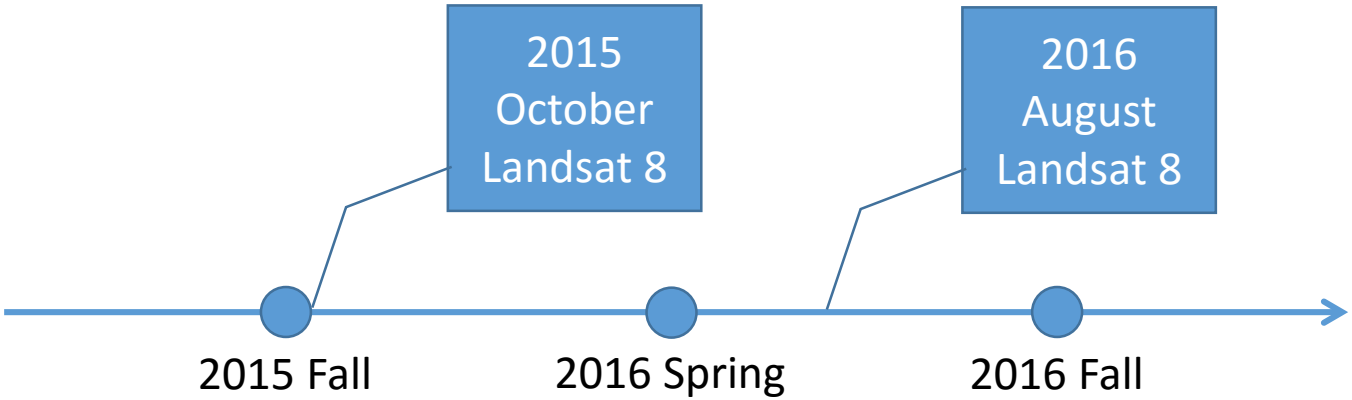
- Three-season sets
  - 1995/11/8
  - 1996/4/16
  - 1996/8/22

  - 2010/11/1
  - 2011/5/28
  - 2011/8/16

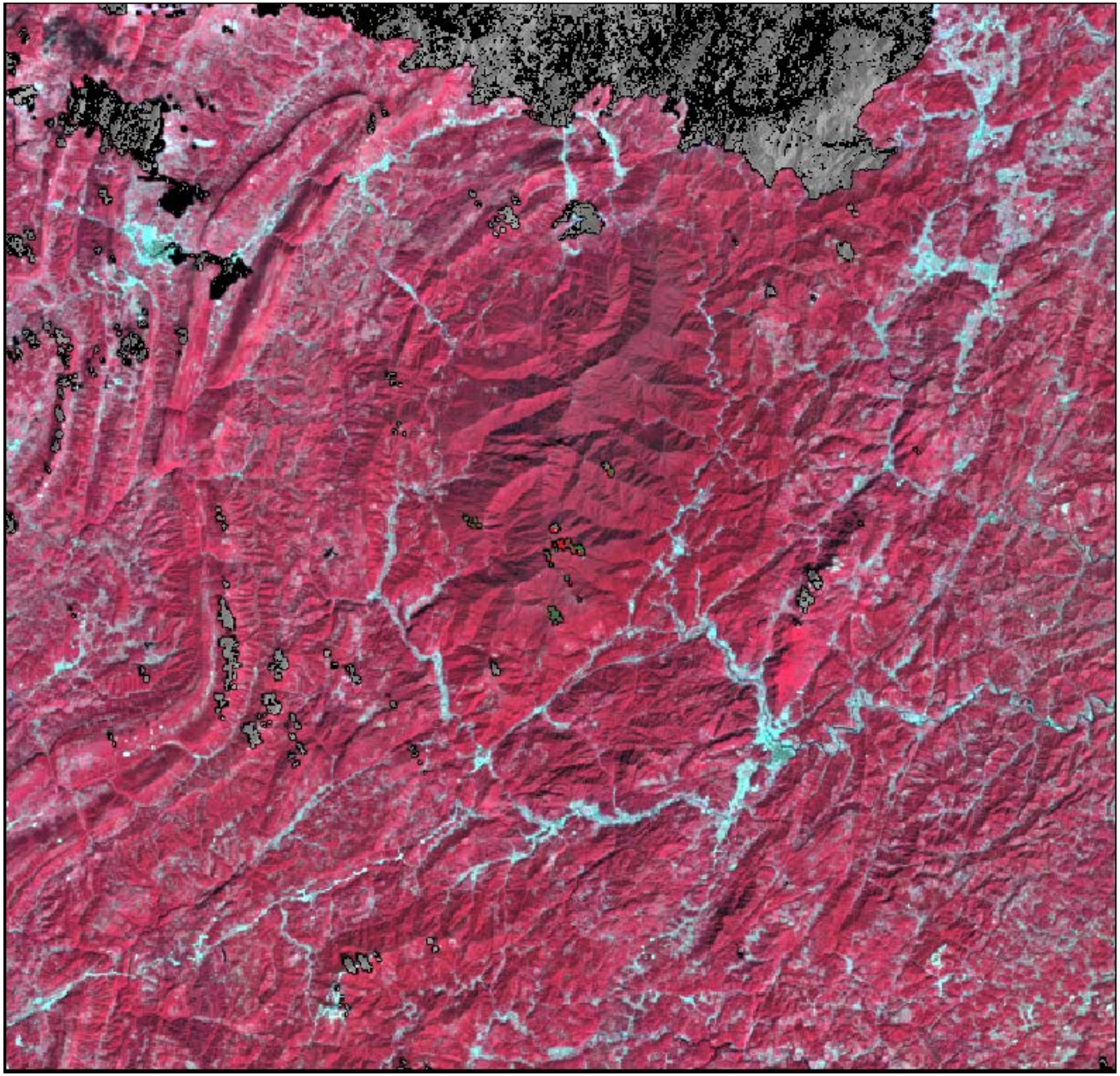
- Single images
  - 1996/8/22
  - 2000/5/13
  - 2011/5/28
  - 2011/8/16
- Landsat 8 OLI
  - 2013/10/8
  - 2014/7/23
  - 2015/10/14
  - 2016/8/29

Landsat 8 OLI vs. Digital Hemispherical Photographs (DHP)

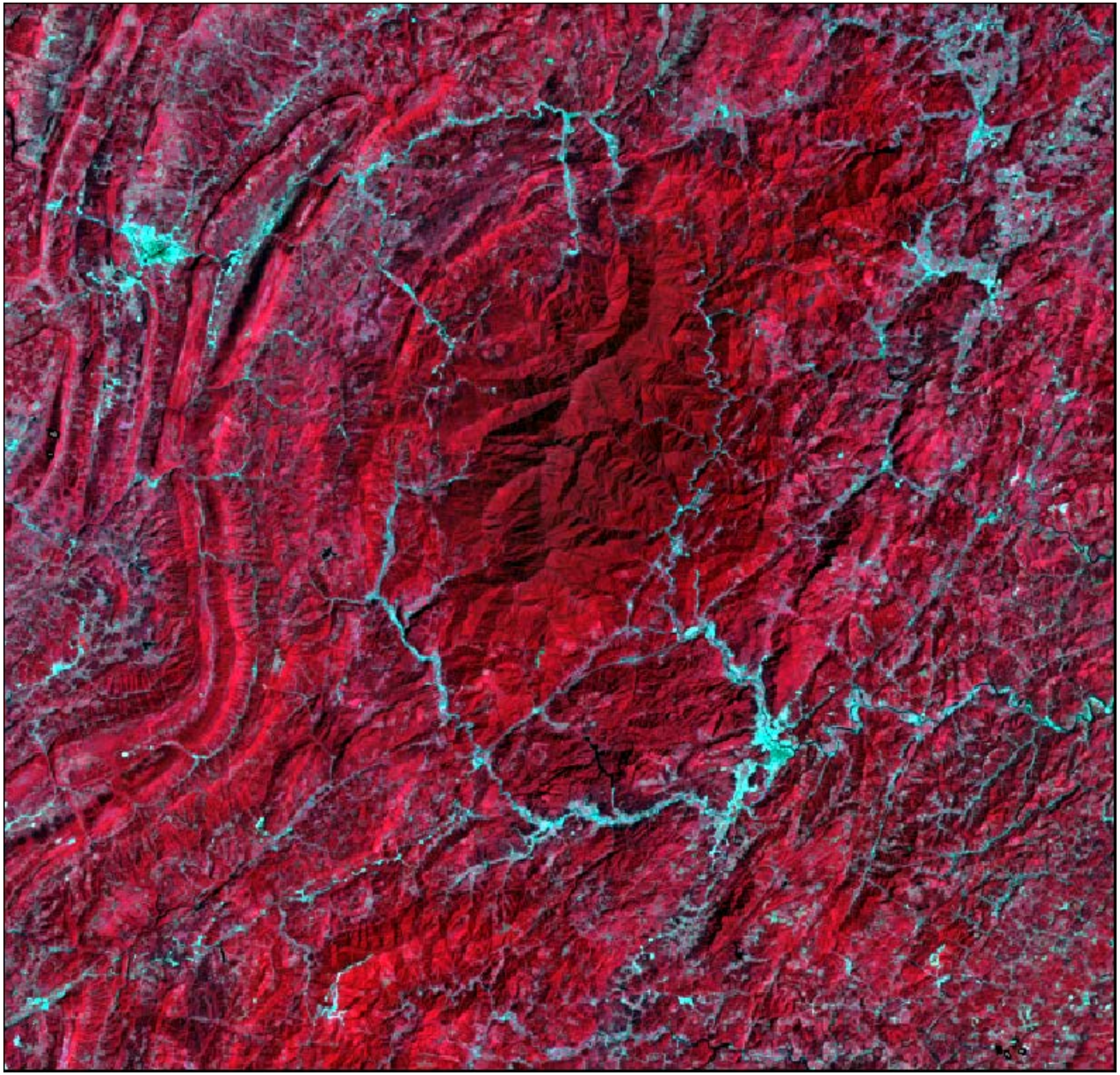
- 2016/8/29 Cloud free Landsat 8 OLI image, most recent
- 2015/10/14 Landsat 8 image, match 2015 Fall DHP



Landsat 8 Image - 2015 October



Landsat 8 Image – 2016 August



Landsat Processing

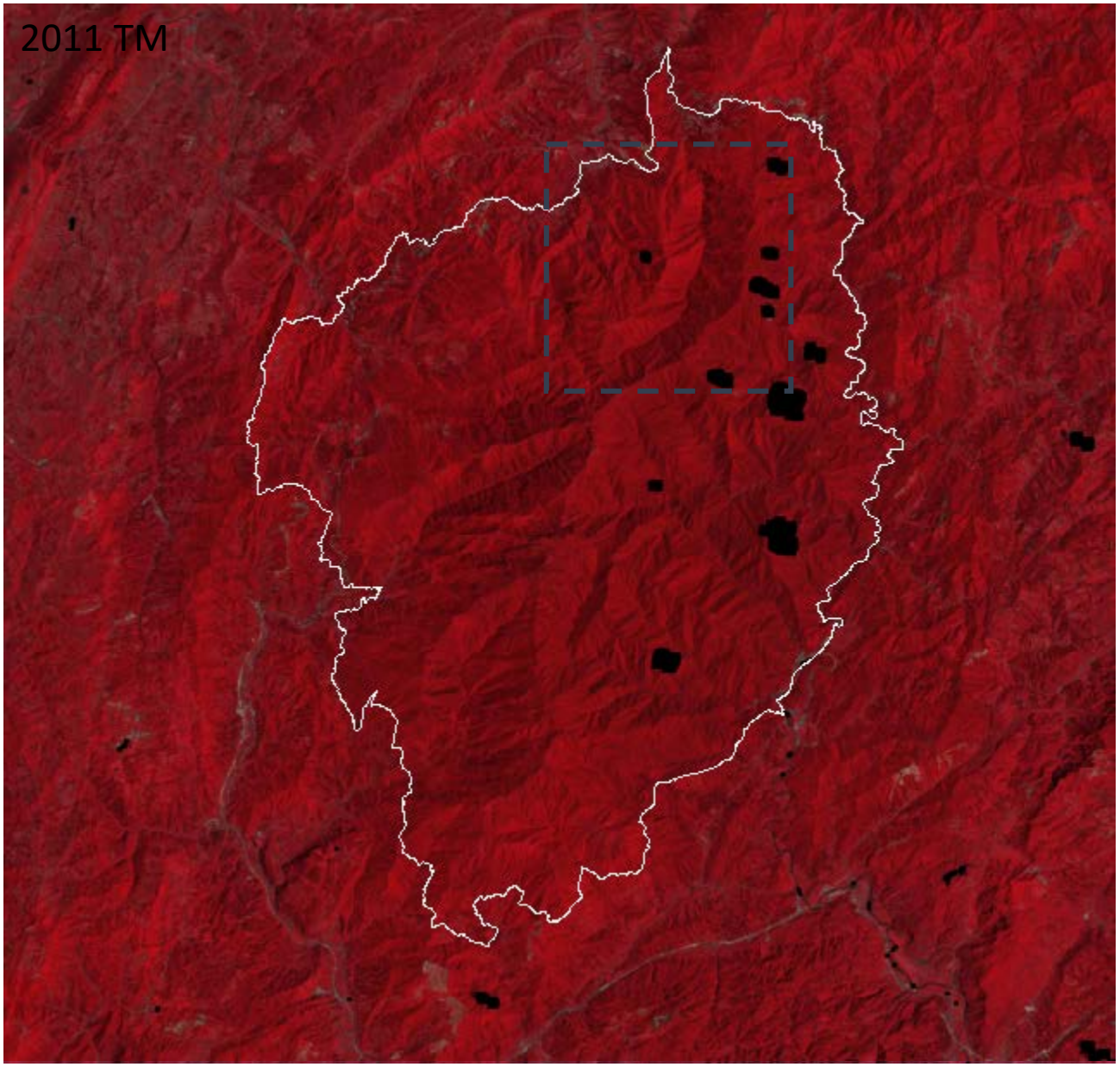
Landsat-derived CFC

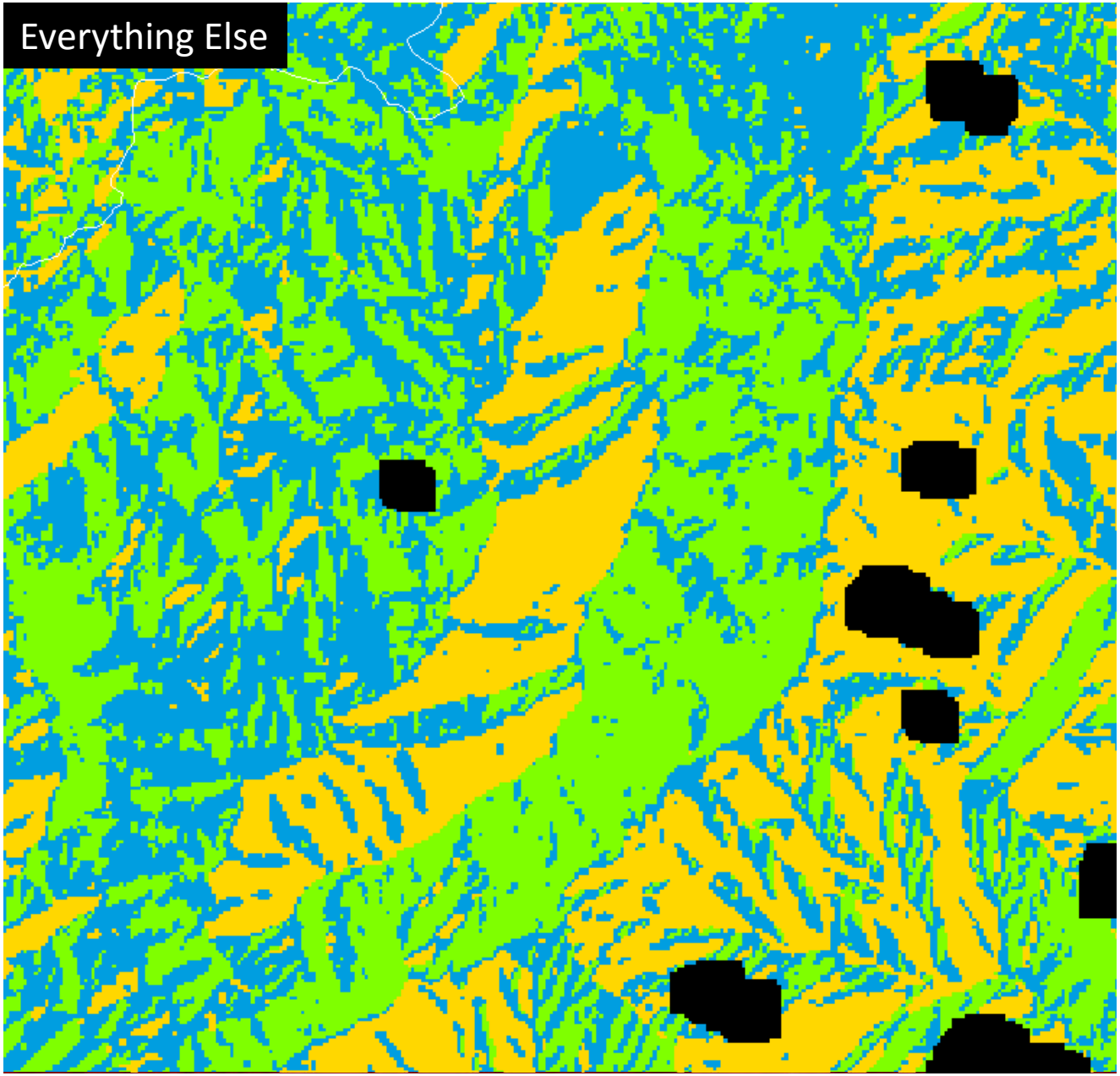
- Selected relatively cloud free summer Landsat imagery
  - August 22nd, 1996
  - August 16th, 2011
- Generated illumination strata
- Applied mixture model
  - Estimate how each pixel's area is divided up among different cover types

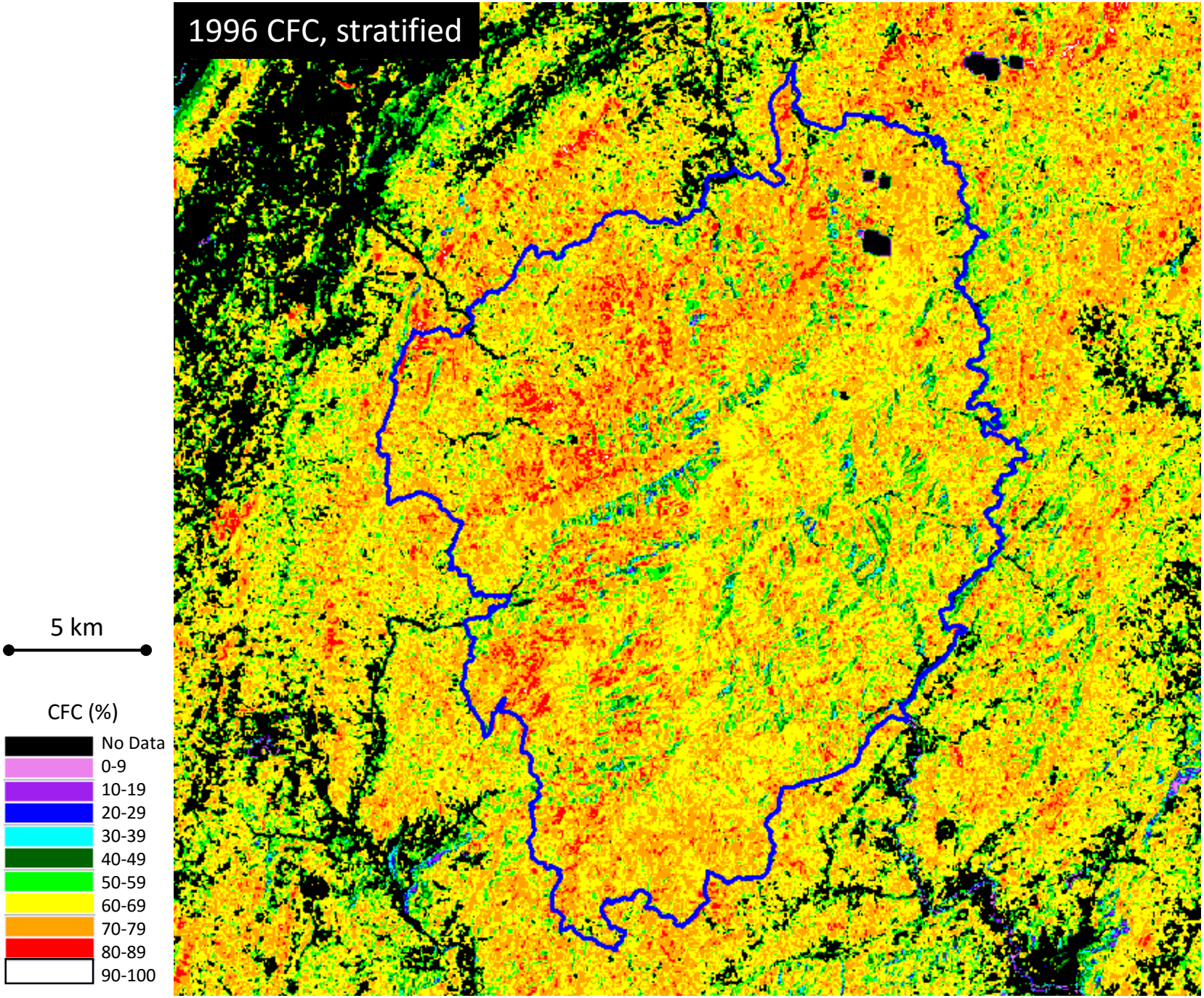
$$\rho_{\ pixel} = \sum_{j=1}^{n} \rho_e * f_e$$

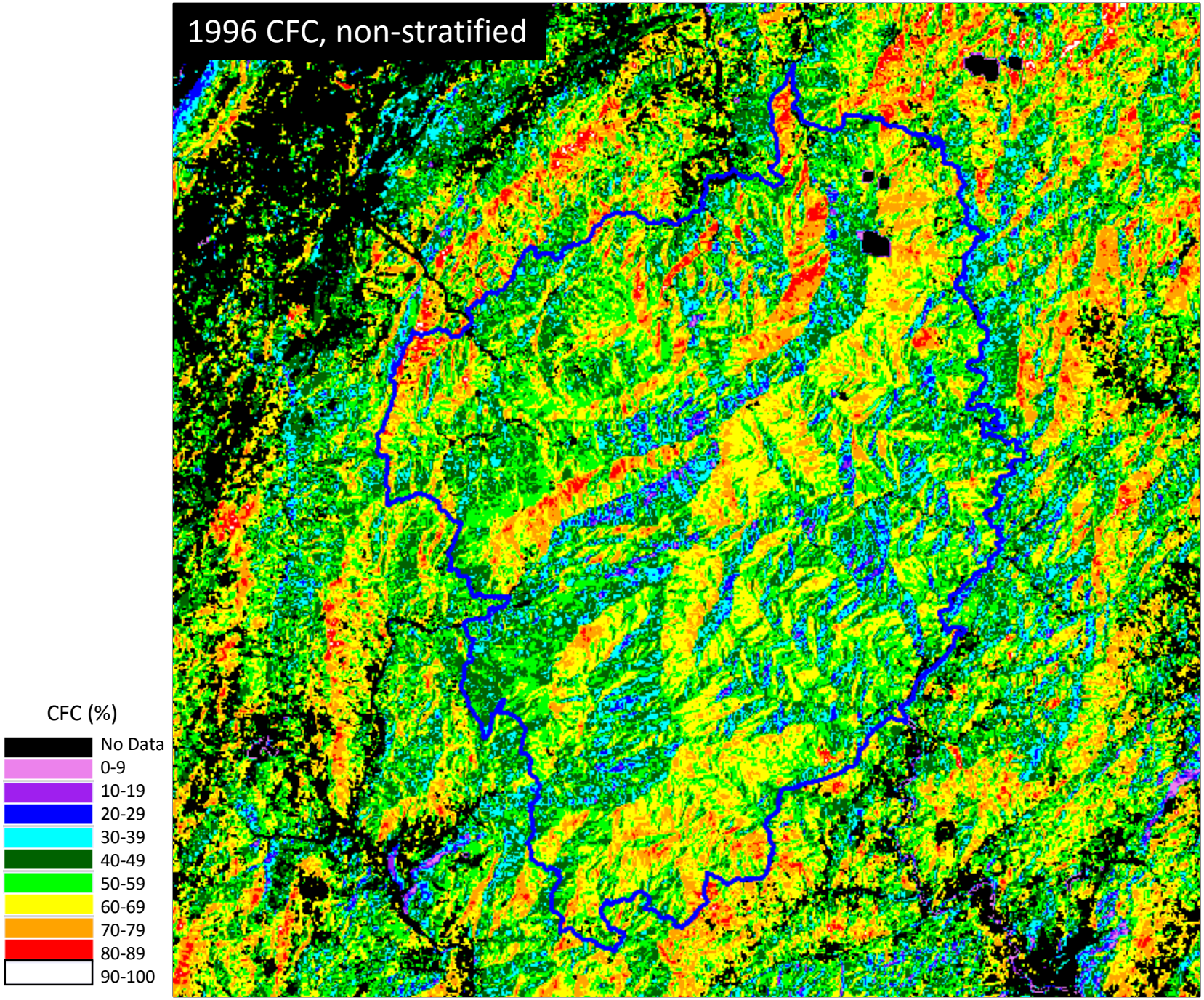
  - Selected pure full canopy pixels and bare soil pixels
  - Calculated CFC

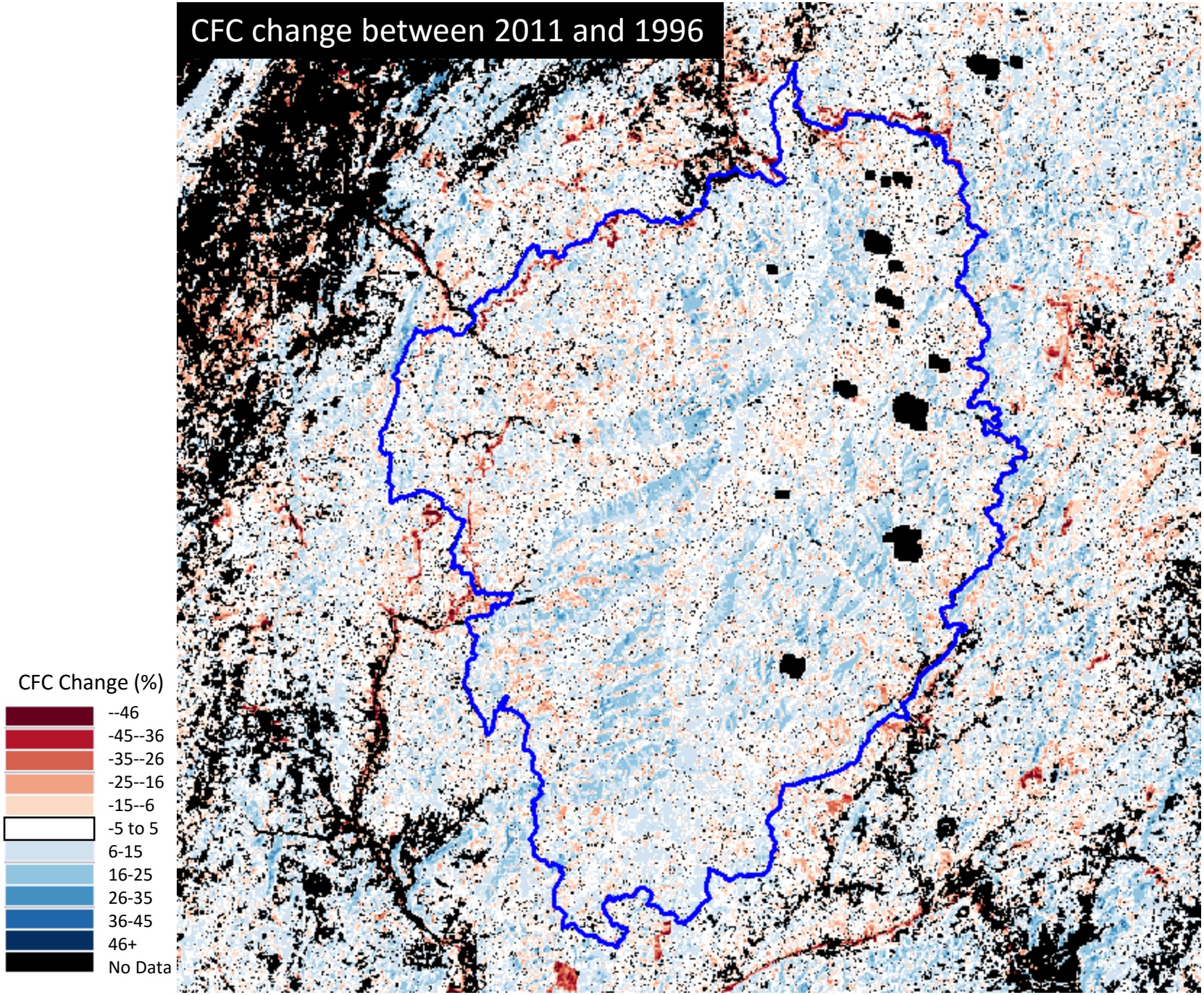
$$\mathrm{CFC} = \frac{V_{\mathrm{pixel}} - V_{\mathrm{open}}}{V_{\mathrm{canopy}} - V_{\mathrm{open}}}$$


2011 TM


Everything Else

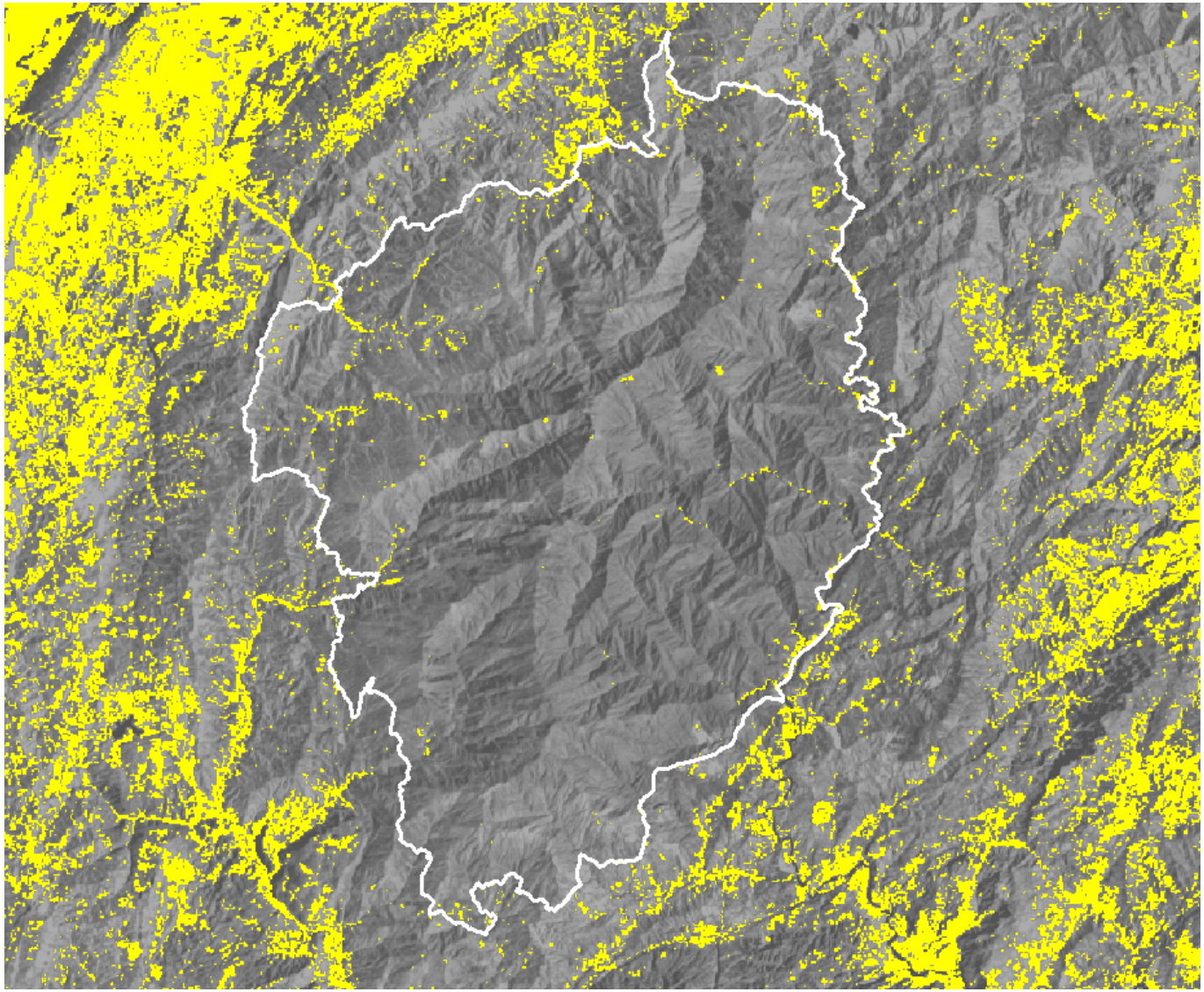

1996 CFC, stratified
5 km
CFC (%)
No Data
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-100


1996 CFC, non-stratified
CFC (%)
No Data
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-100

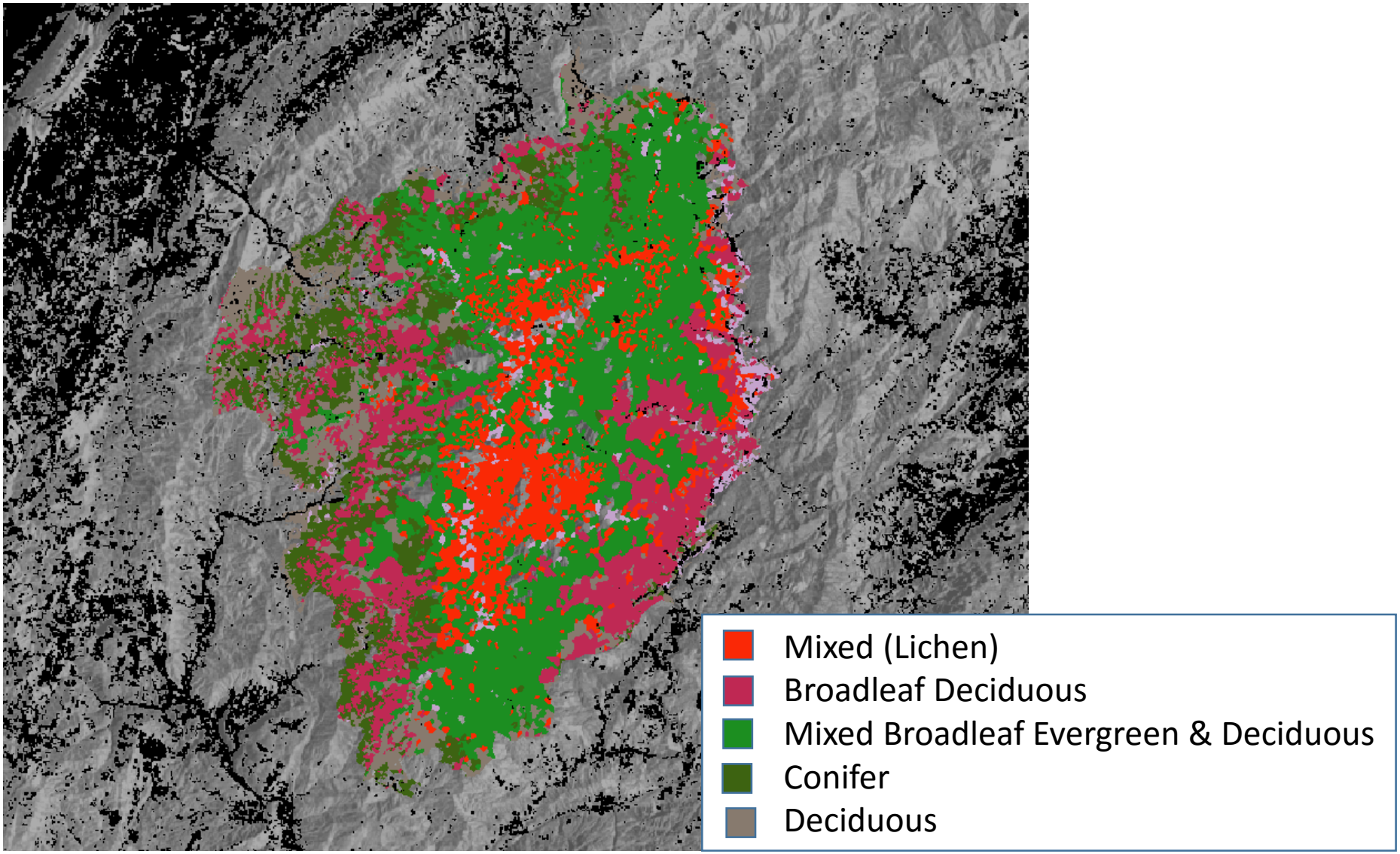

CFC change between 2011 and 1996
CFC Change (%)
--46
-45--36
-35--26
-25--16
-15--6
-5 to 5
6-15
16-25
26-35
36-45
46+
No Data

Vegetation Type Map

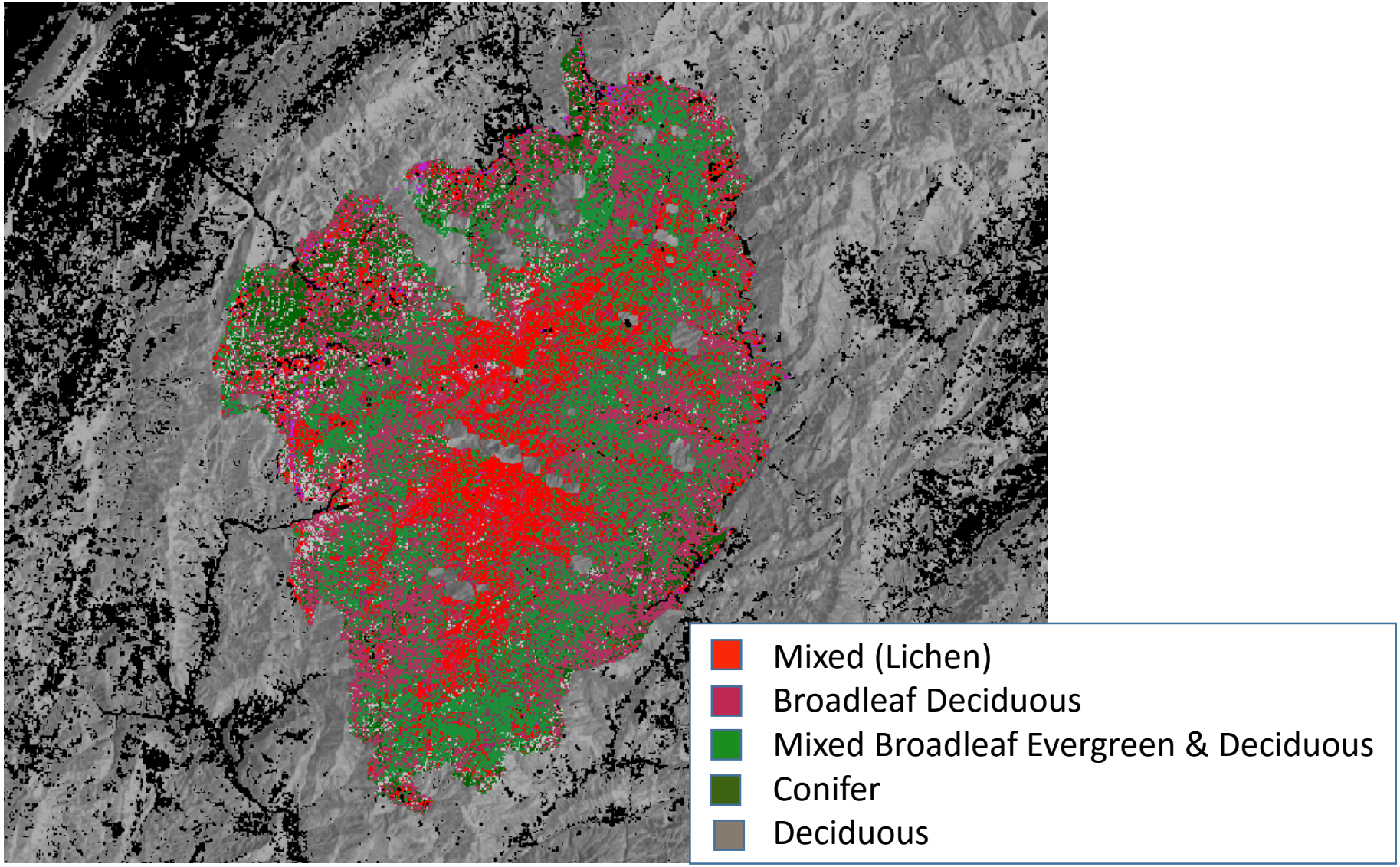
Binary Forest Map yellow = non-forest



Veg Map Through GEF Project



Veg Map - Landsat initial multi-date

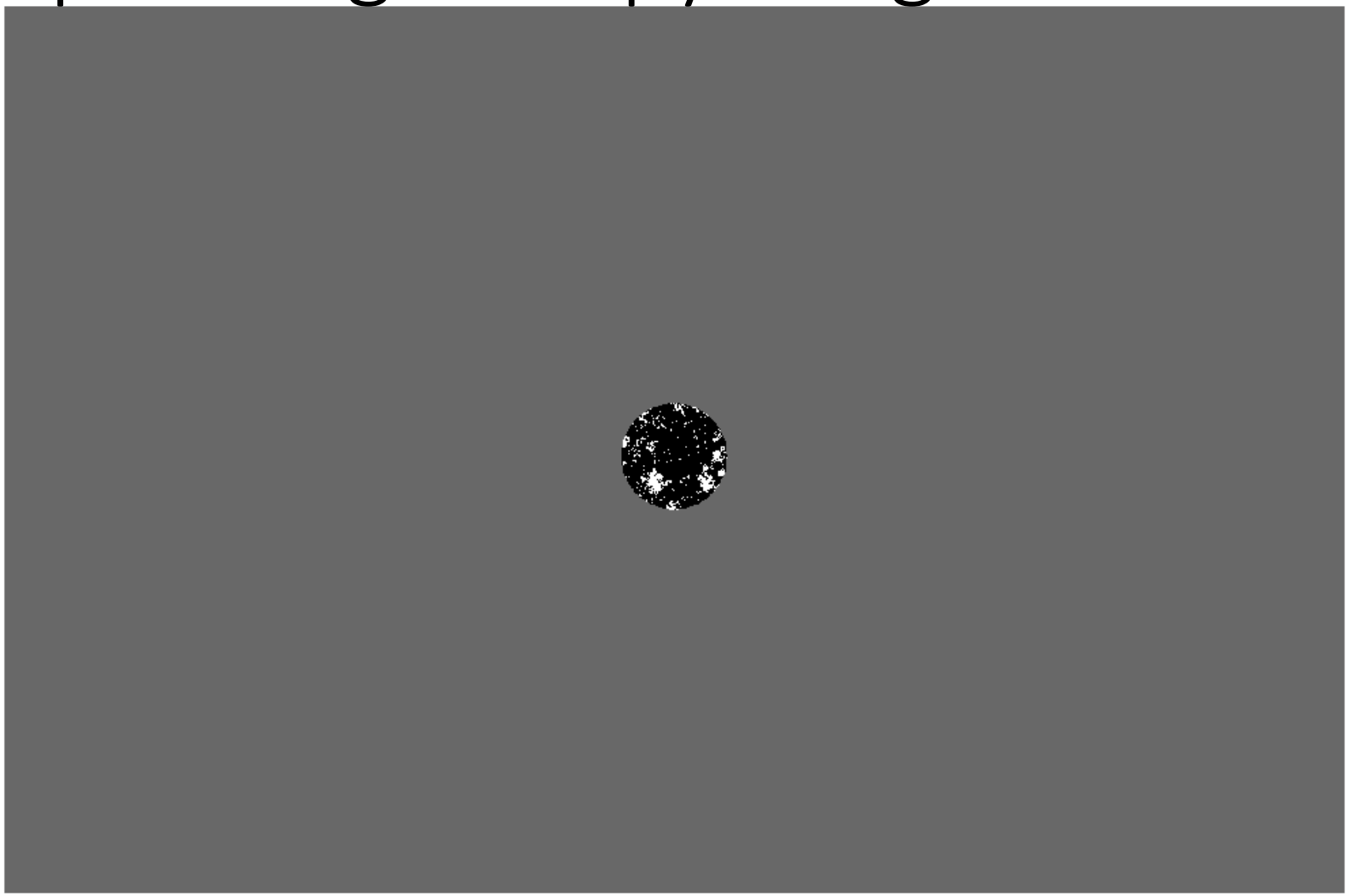


Ground-based Canopy Data

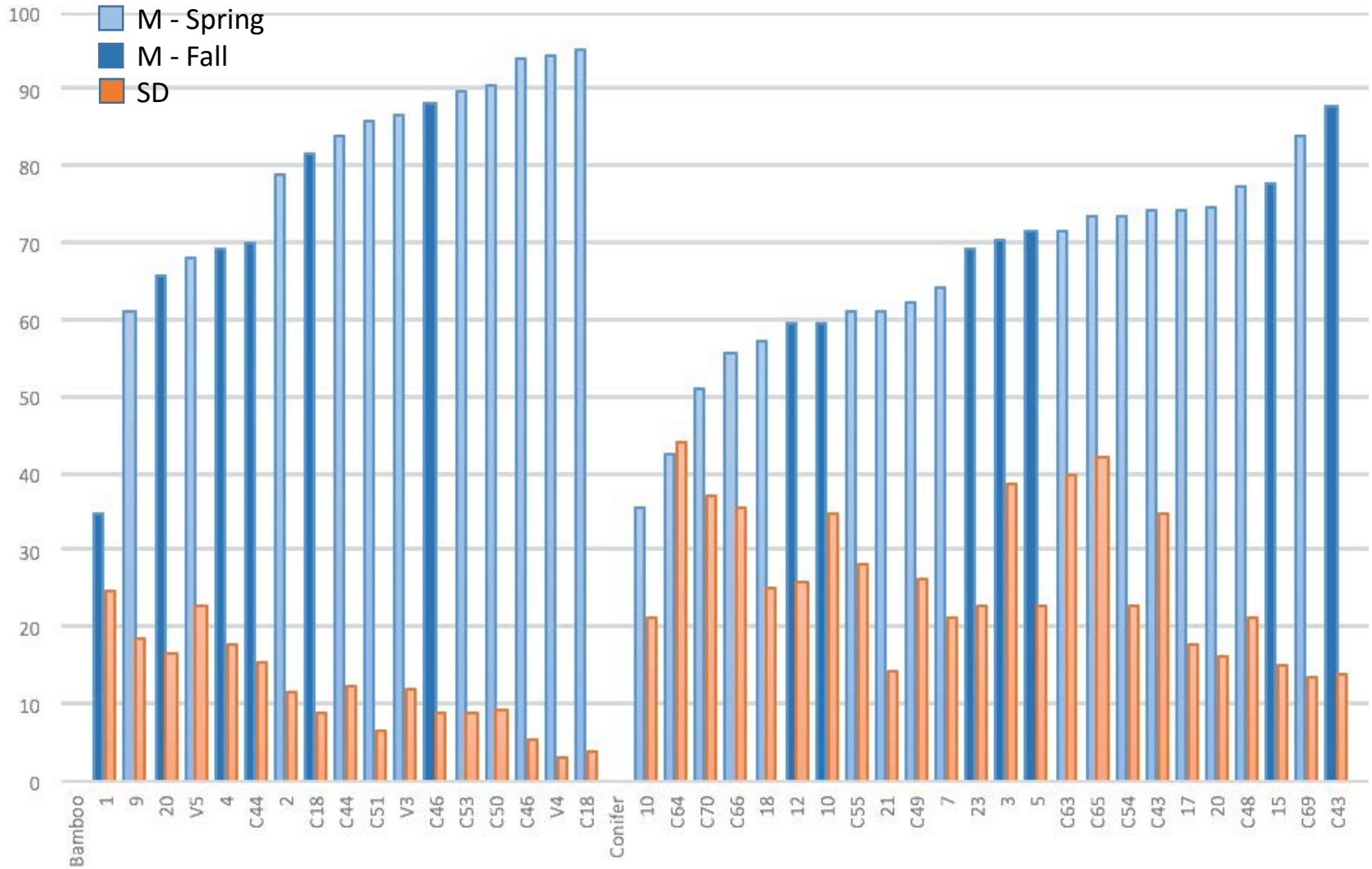
Data Summary

Cover Type	Plot Count							
	2016 March	2015 October	2015 April	2014 March	2013 March	2012 October	Total	Unique plots
Bamboo	5 (3 new)	3 (2 new)	4	0	2 (0 new)	3	17	12
Deciduous	4 (2 new)	7 (2 new)	6	0	4 (2 new)	4	25	16
Conifer	11 (10 new)	1 (1 new)	0	0	6 (1 new)	7	25	19
Evergreen Broadleaf	7 (3 new)	12 (4 new)	11	0	2 (2 new)	2	34	22
Mixed Evergreen/Decidous	14 (8 new)	22 (4 new)	20	3 (3 new)	9 (3 new)	5	73	40
Total	41	45	41	3	23	21		
Sample points per plot	5 (35 plots), 13 (6 plots)	5 (43 plots), 13 (2 plots)	17 (1 plot), 13 (12 plots), 5 (28 plots)	5	9	5		
						Total	174	112

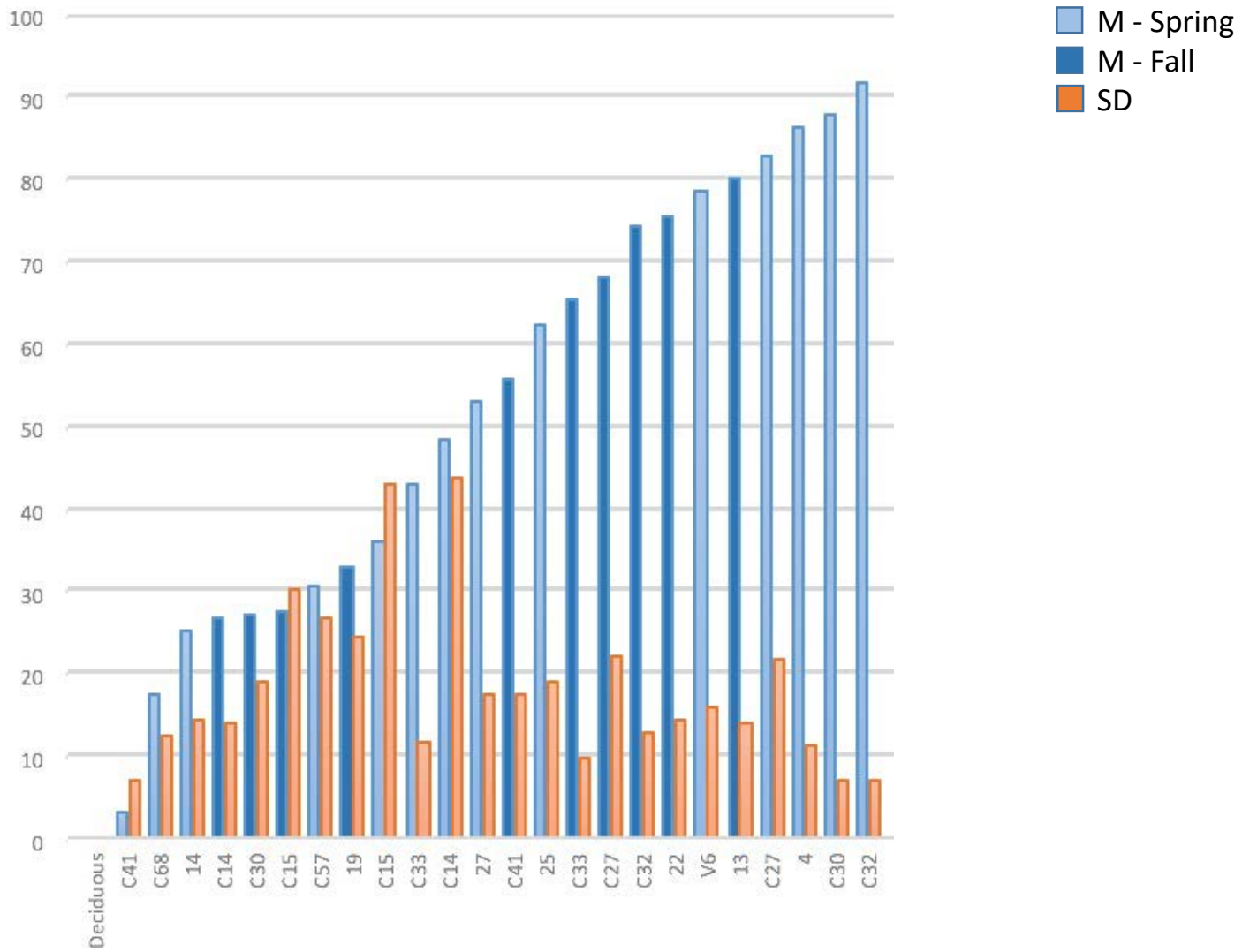
Uplooking Canopy Image



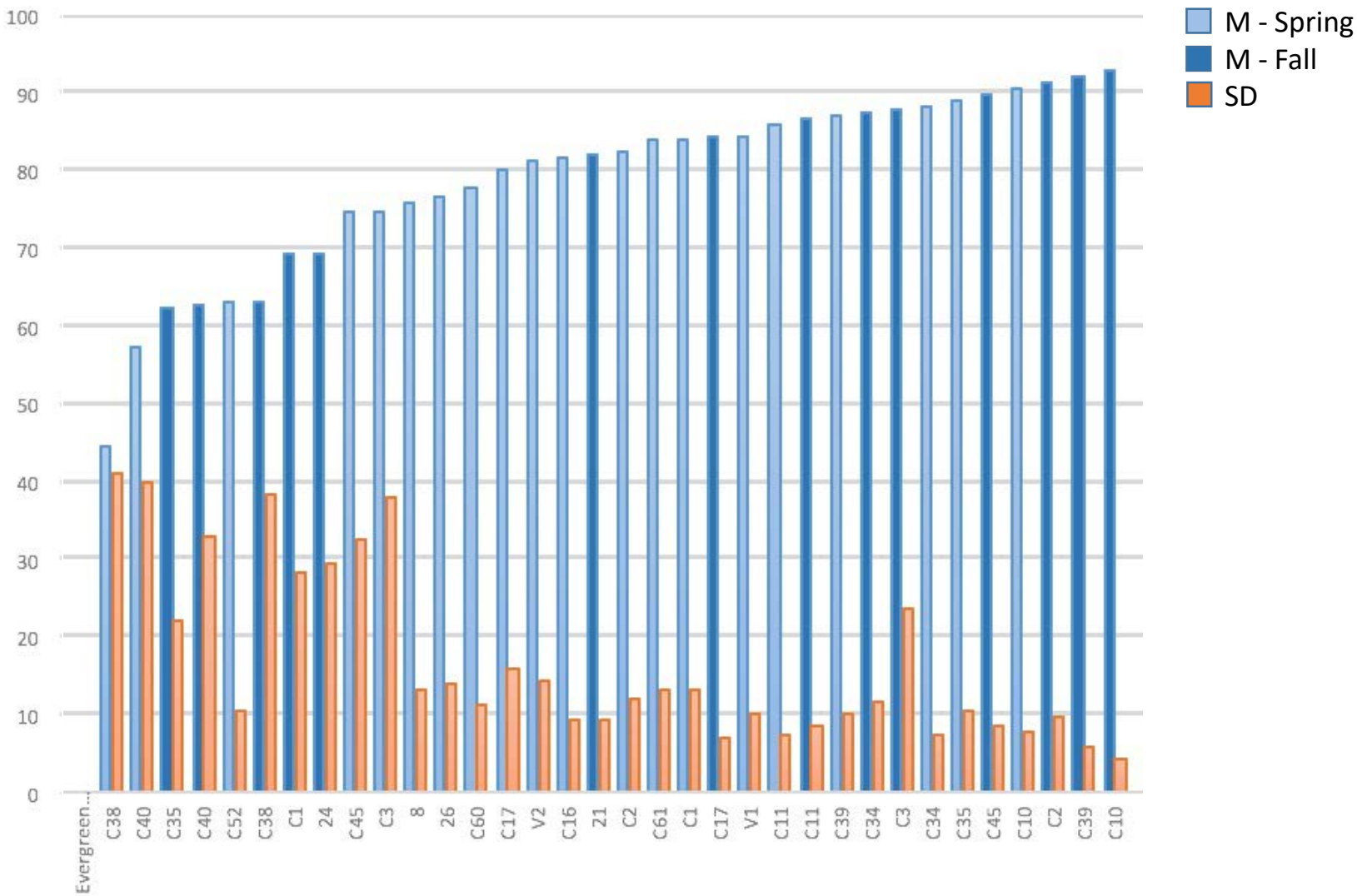
Canopy Data – Bamboo & Conifer



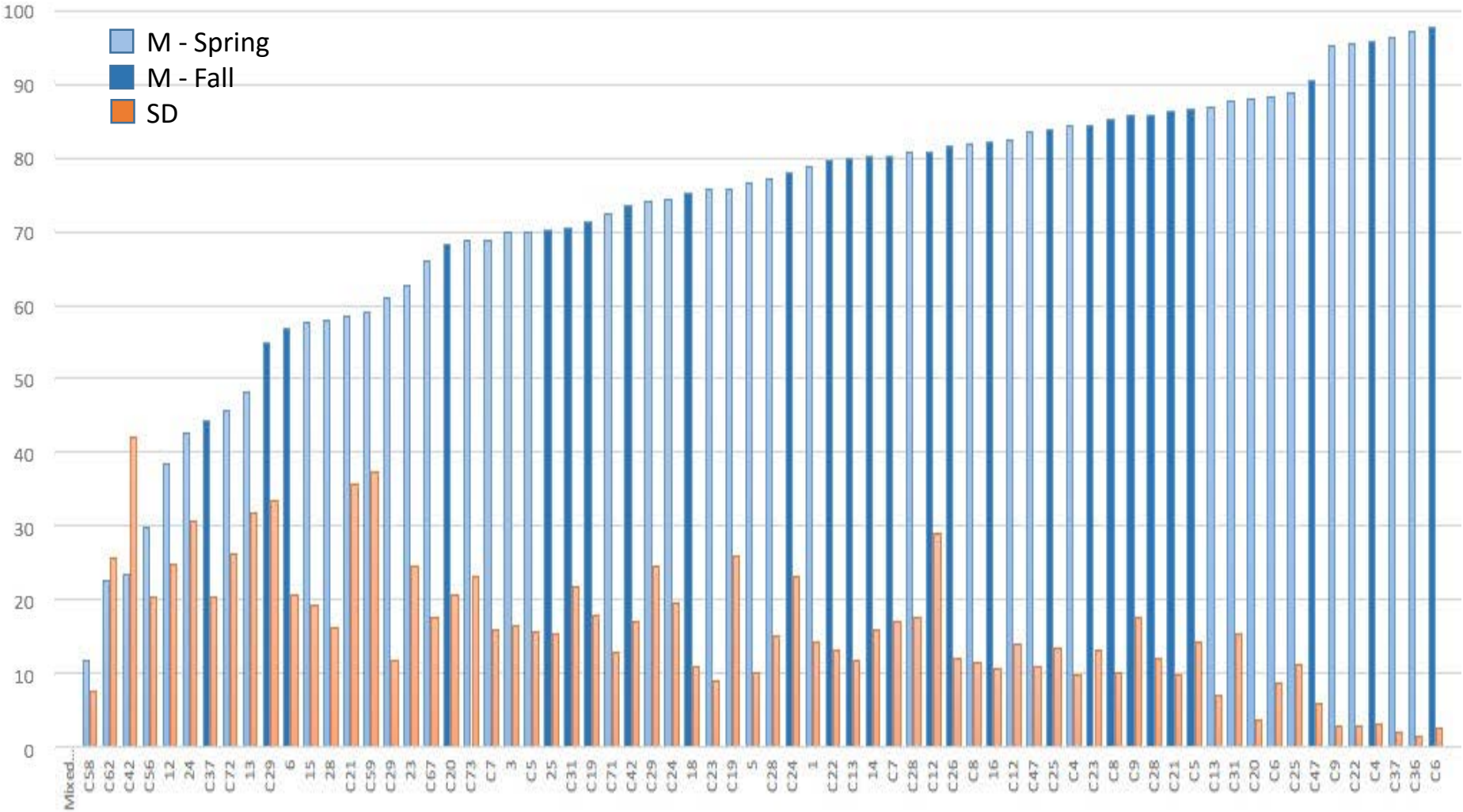
Canopy Data - Deciduous



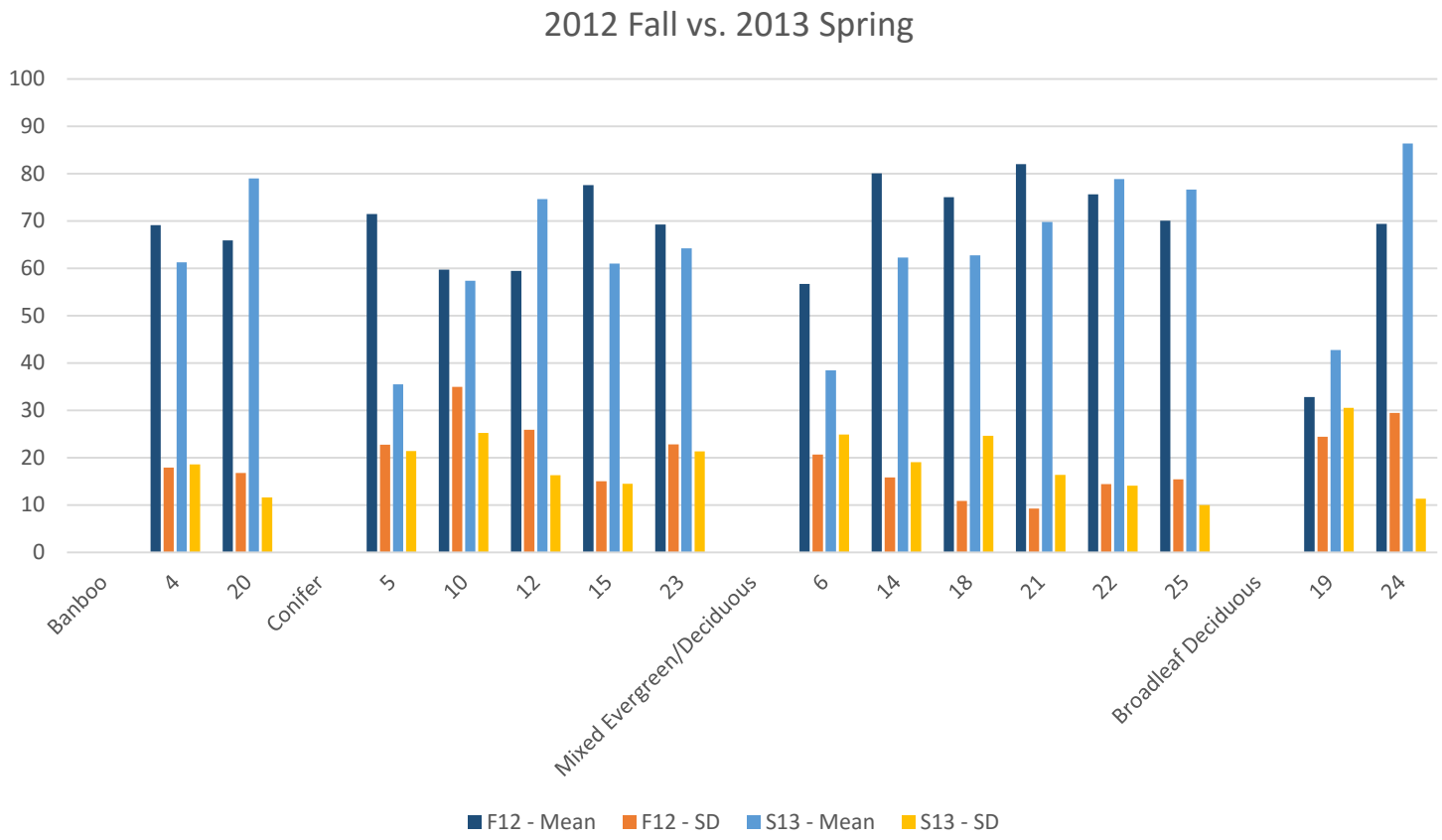
Canopy Data - Broadleaf



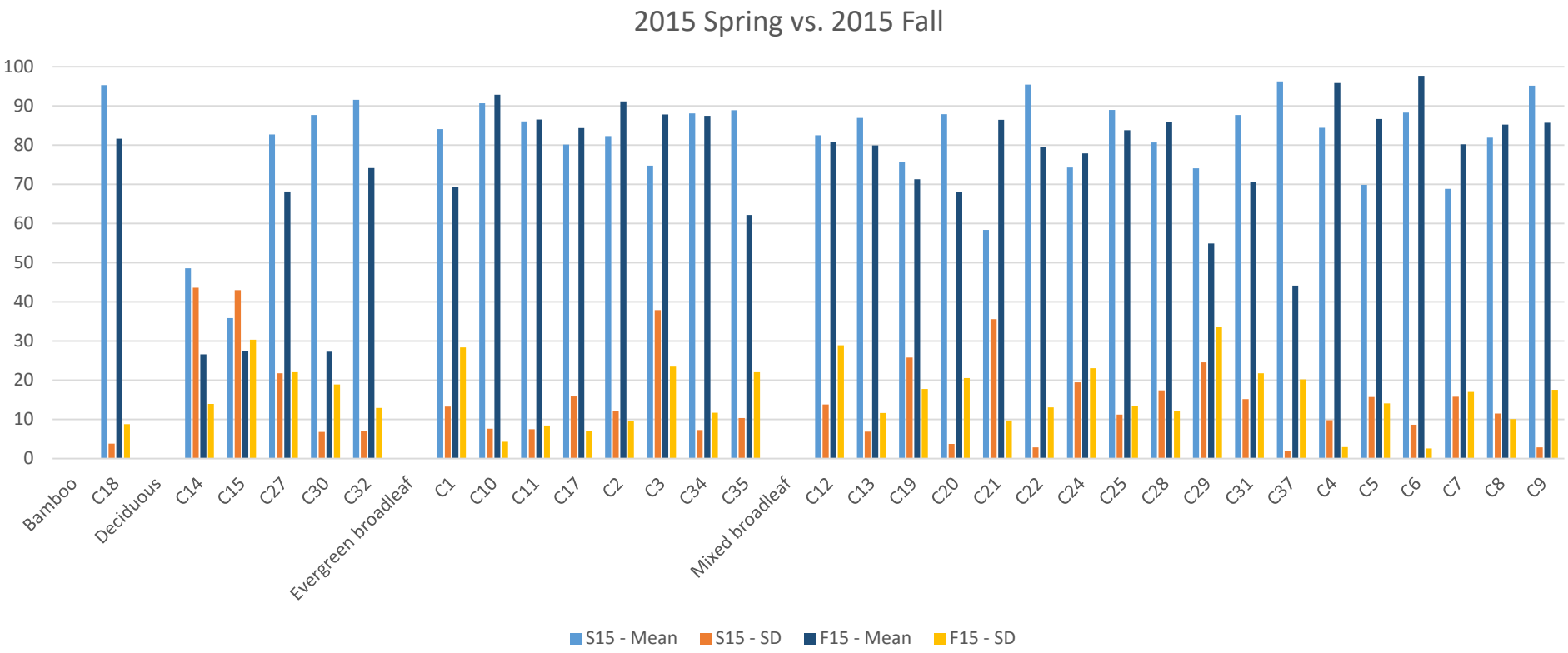
Canopy Data - Mixed



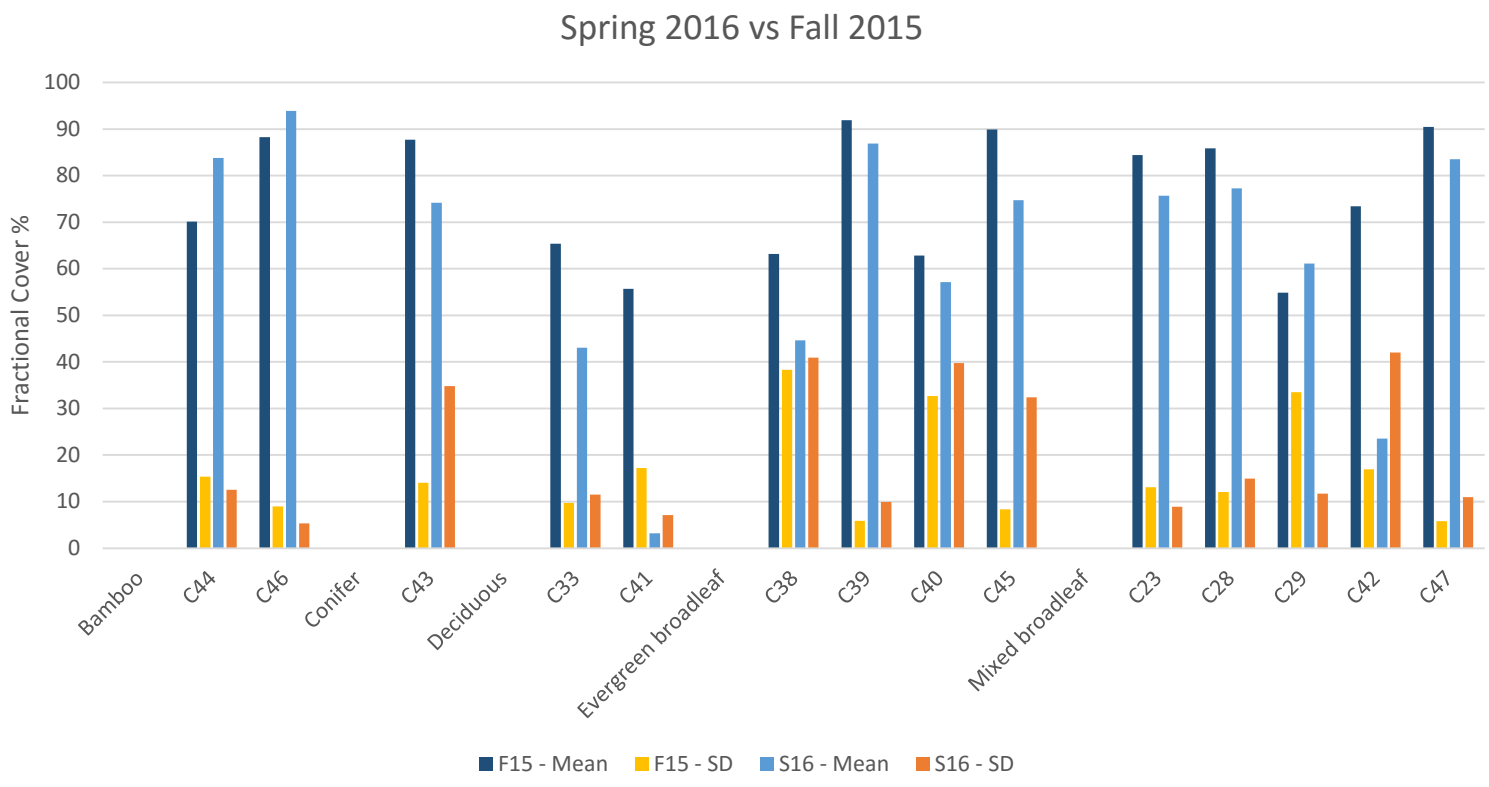
Canopy Data Seasonal Difference



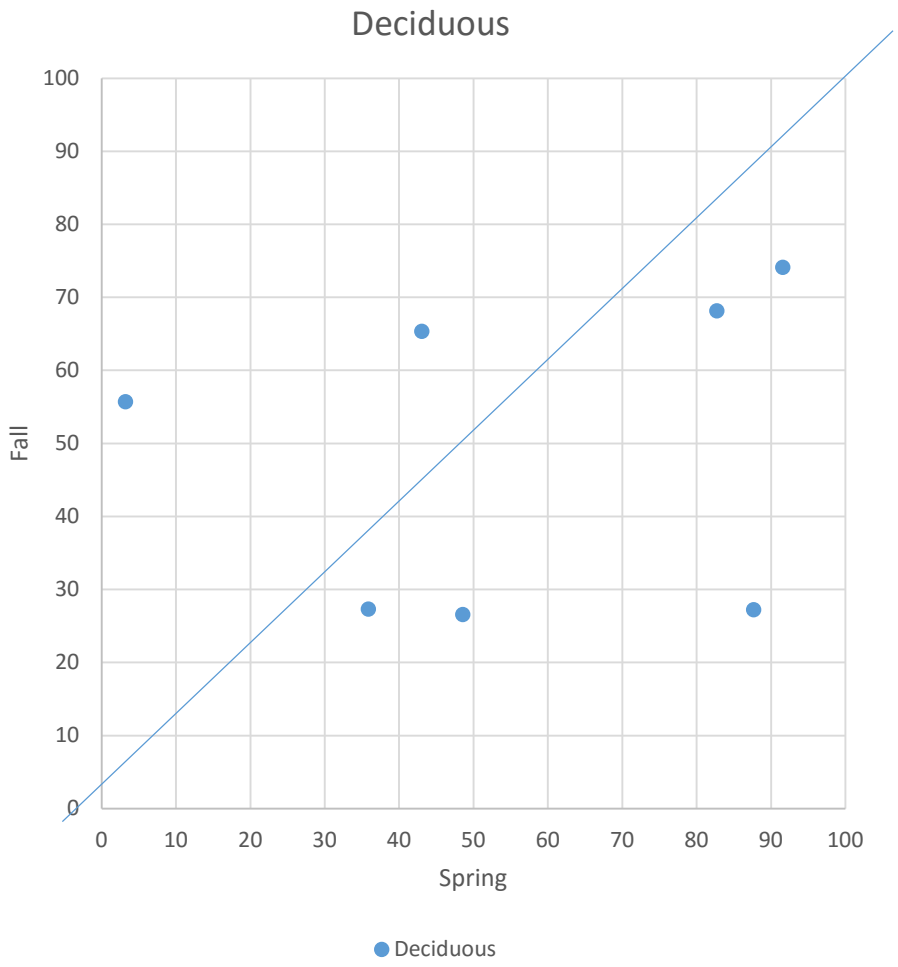
Canopy Data Seasonal Difference



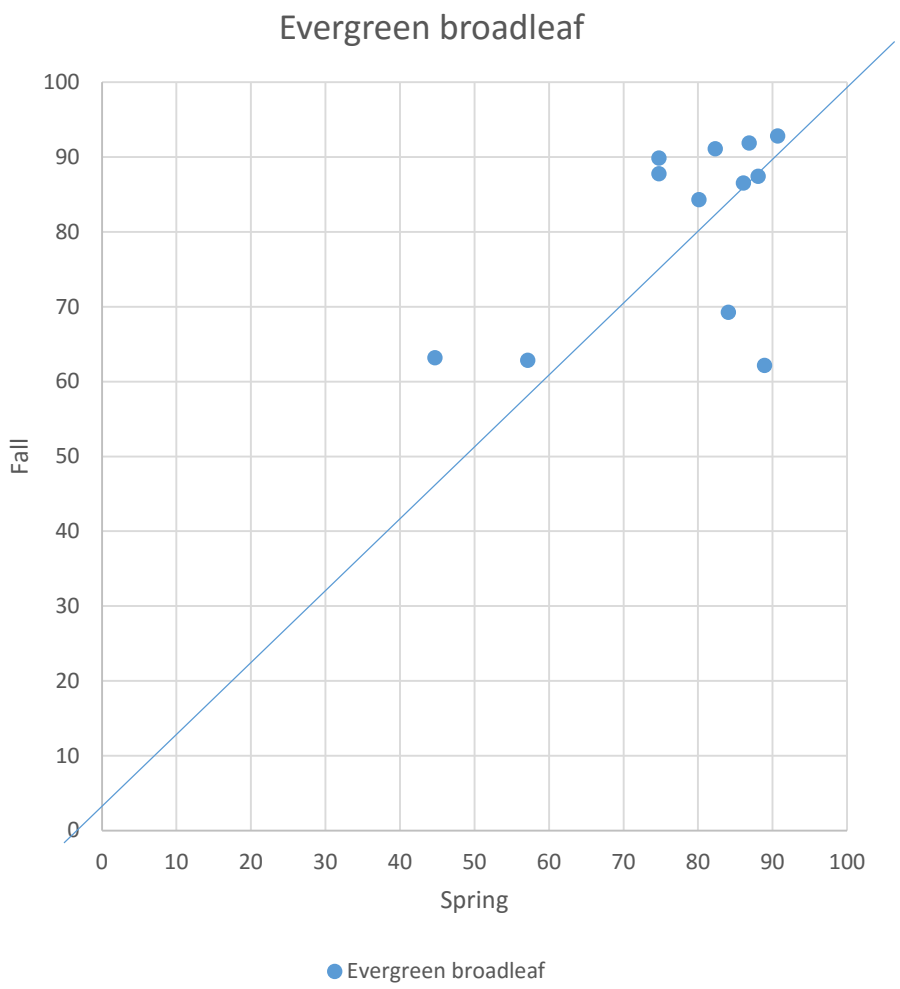
Canopy Data Seasonal Difference



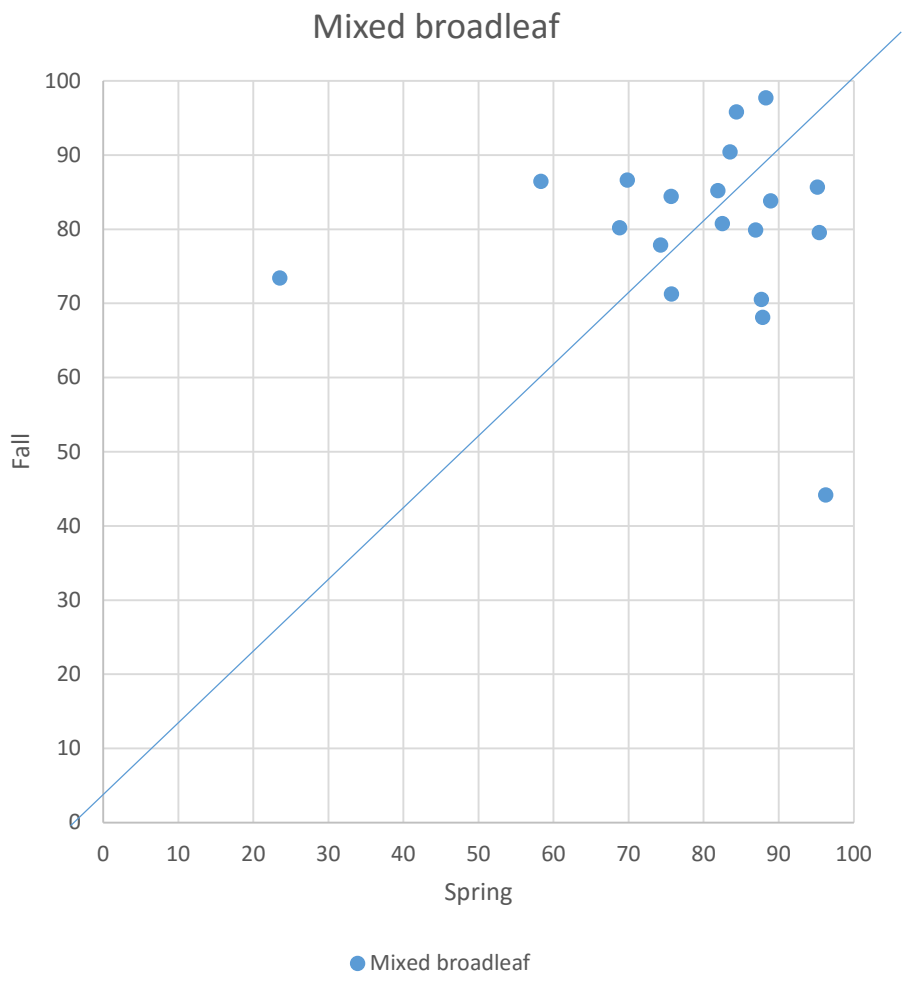
Canopy Data Seasonal Difference



Canopy Data Seasonal Difference



Canopy Data Seasonal Difference

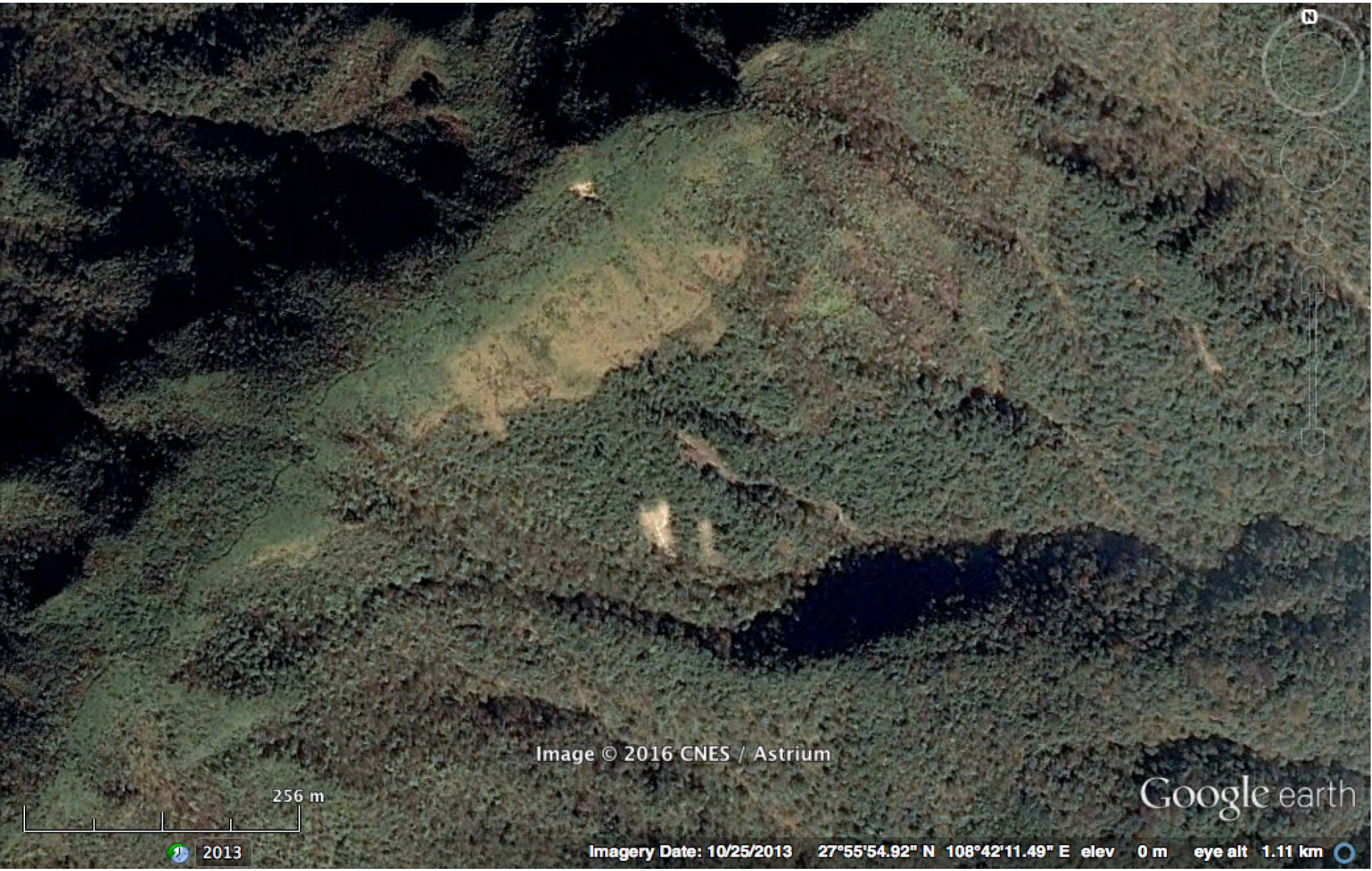


Linking Satellite & Social Survey

Anthropogenic vs. Natural

- Sampling
  - Extract CFC decrease over 10%
  - Sample 500 pixels, 3x3 in size
- Identify causes
  - View Pleiades 2013 image
  - Label sample patches as anthropogenic or natural
- t-test
  - Compare CFC reduction amount with anthropogenic and natural

CFC Patch	CFC Decrease (%, Mean)	Change Type
1	12	Anthropogenic (ag)
2	40	Natural (landslide)
…		
500	23	Anthropogenic (ag)


N
Image © 2016 CNES / Astrium
256 m
Google earth
2013
Imagery Date: 10/25/2013 27°55'54.92" N 108°42'11.49" E elev 0 m eye alt 1.11 km

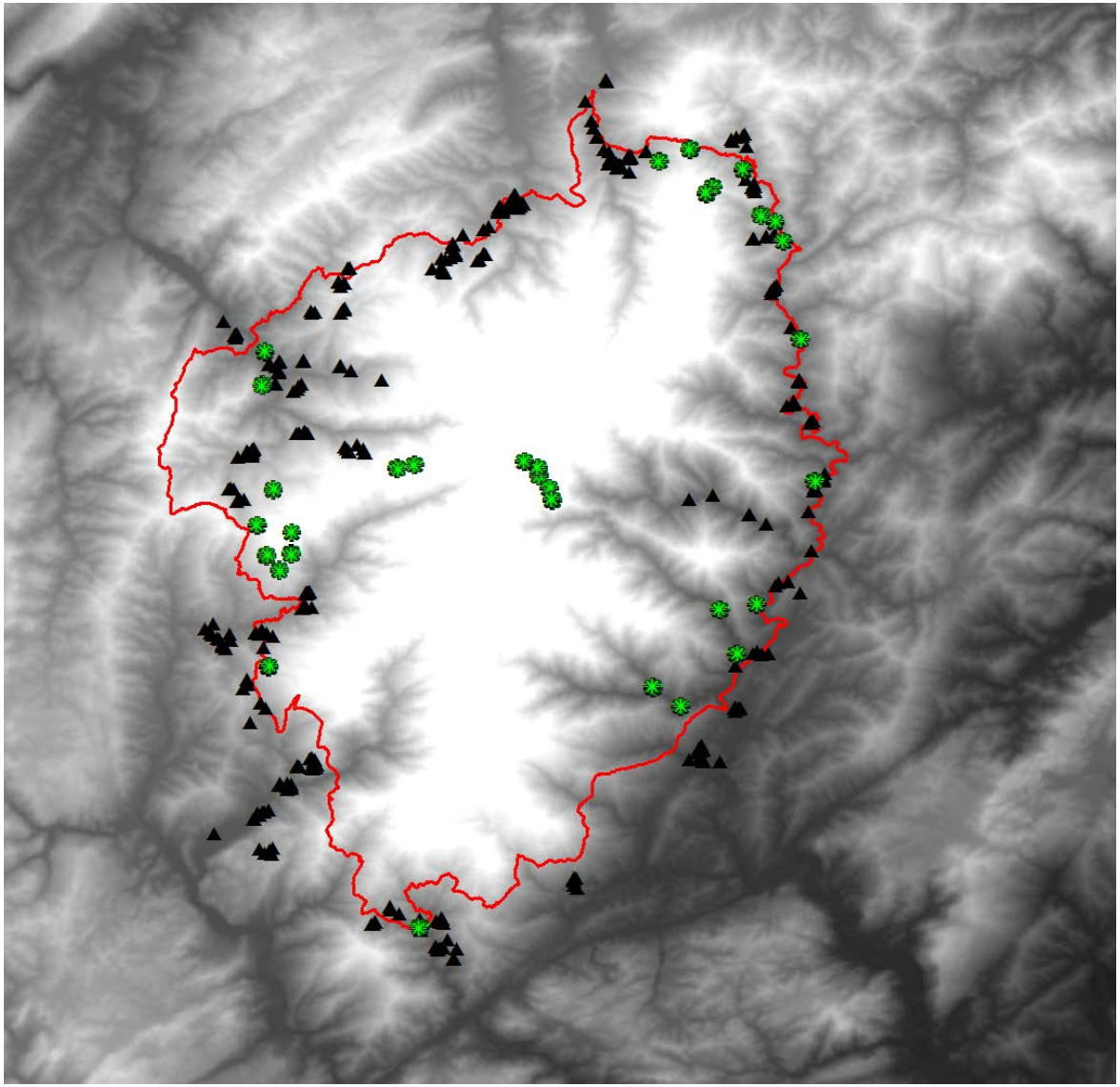
Social Survey Analysis

- Participatory mapping questions such as
  - Where is your land? What do you plant there?
  - Where is your GTGP land? What do you plant there?
- t-test to compare CFC change between GTGP land and non-GTGP land

Land Patch	CFC Change (%, Mean)	Change Type
1	+20	GTGP
2	+4	GTGP
3	-3	Non-GTGP
…		

- ANOVA to compare CFC change and demographic information, e.g., ethnicity and education

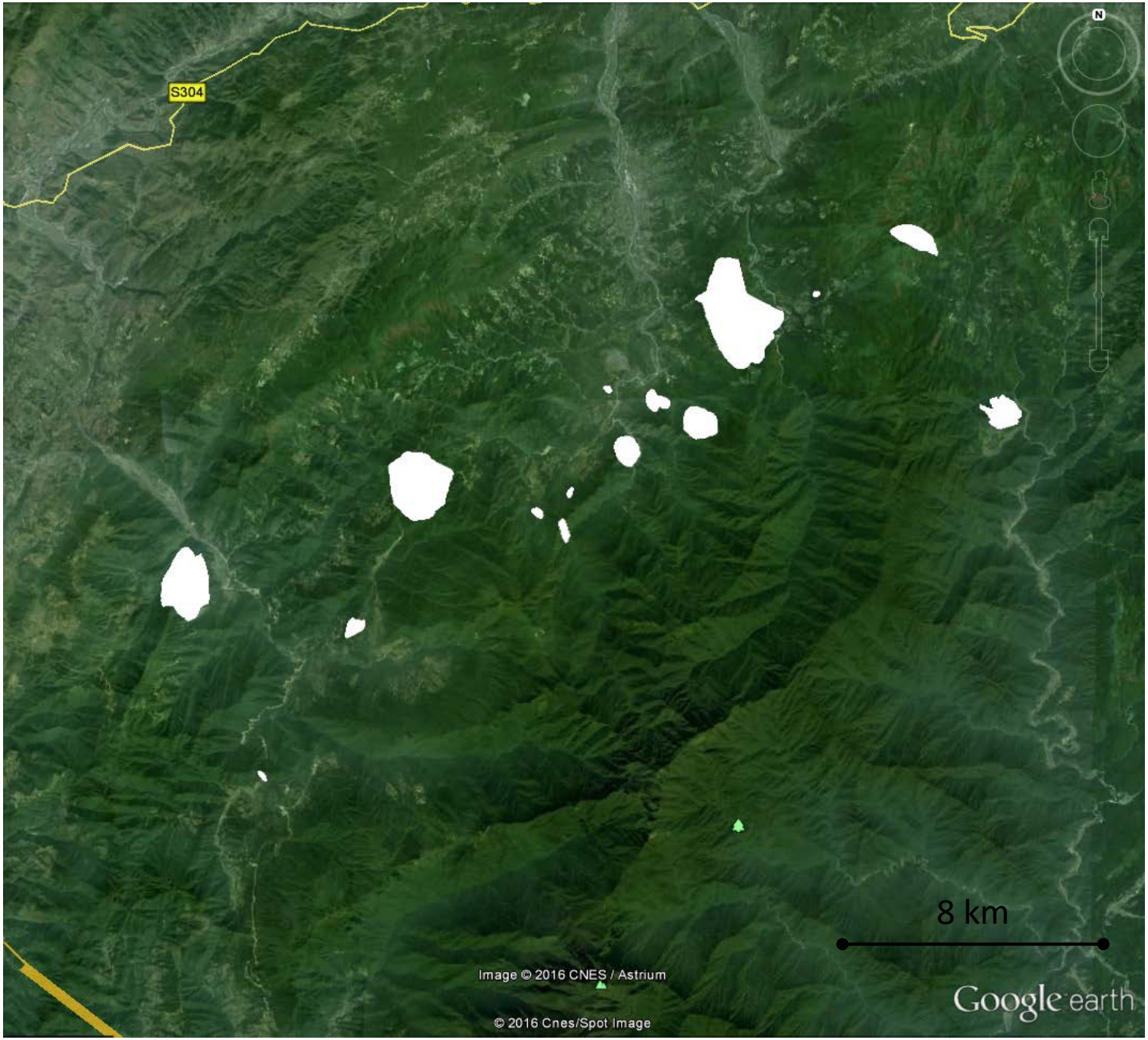
Survey Efforts in FNNR



10 km

DHP 2012-2013

P. Mapping 2014


S304
8 km
Image © 2016 CNES / Astrium
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Google earth