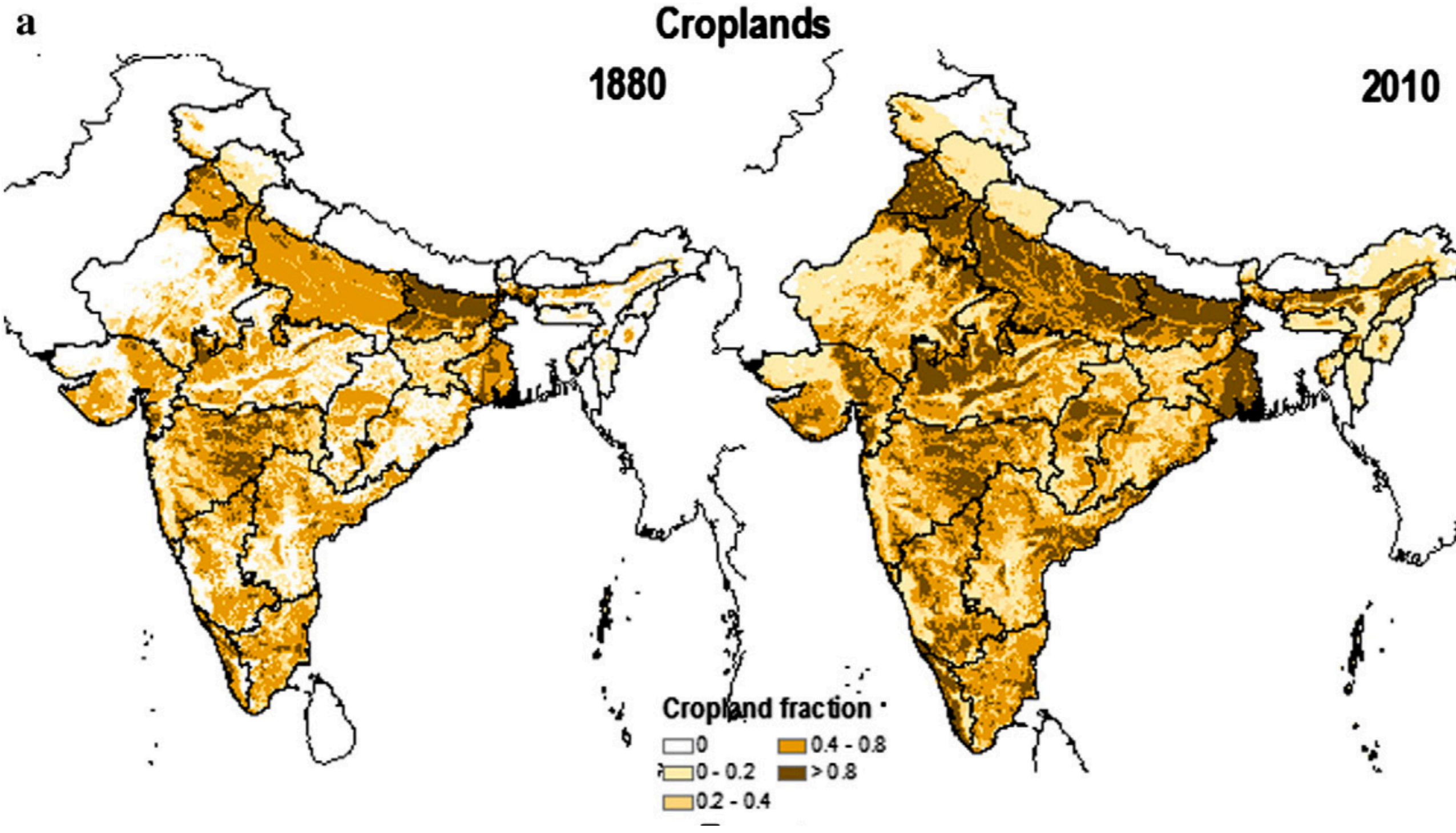
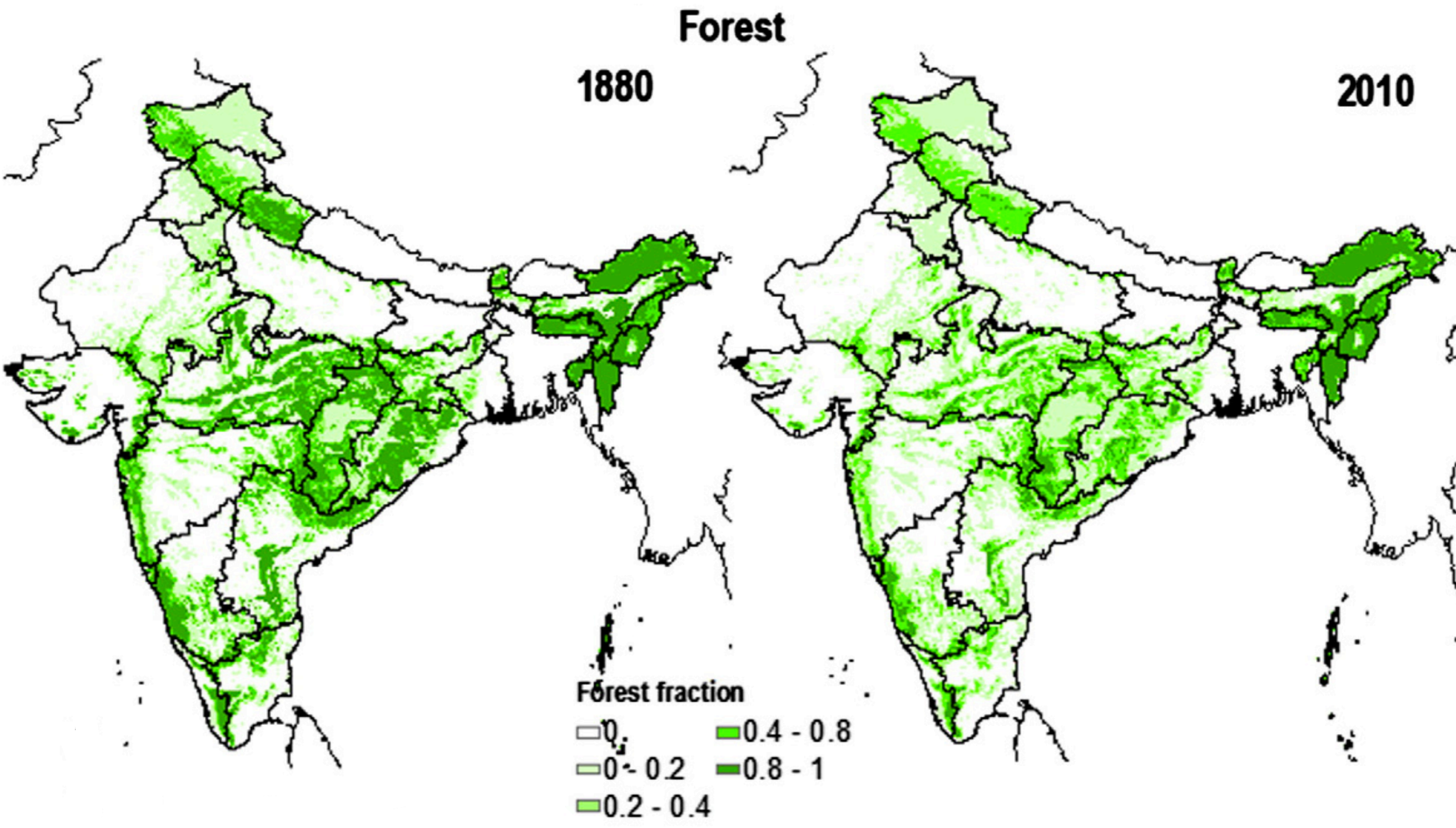
Assessing the Extent and Drivers of Forest Plantation Establishment in Andhra Pradesh

Randolph H. Wynne, Valerie A. Thomas, Haripriya Gundimeda, Gregory S. Amacher, Kelly M. Cobourn, Gunnar Köhlin, Paige T. Williams, Snehal More



Tian et al. 2014 Global and Planetary Change 121: 78–88



Tian et al. 2014 Global and Planetary Change 121: 78–88

Conversion from rice to typical clonal hybrid Casuarina plantation. The Forest Survey of India notes tree cover > 11,100 km^2 was added during the period 2001 to 2015.

What might be causing this conversion to forest plantations from agriculture?

- Productive pest-resistant clones of Eucalyptus, Subabul and Casuarina
- Reduced human inputs compared to crops
- ‘Absentee’ landlords
- Marginal agricultural lands
- Desire to maintain land ownership
- Policies (National Forest Policy of 1988, state-specific)

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PROJECT

ANDHRA PRADESH FORESTRY

OVERVIEW DETAILS FINANCIALS PROCUREMENT RATINGS RESULTS MAP DOCUMENTS NEWS & MEDIA

ABSTRACT*

The report discusses how this project will finance a 6-year program to support: (a) forestry works on about 355,000 ha. This will consist of regenerating or afforesting degraded forest areas on about 173,000 ha with multi-tier coverage under

India BSE 314.50 NSE 313.95

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No.3A/86-FP
Ministry of Environment and Forests
(Department of Environment, Forests & Wildlife)

Paryavaran Bhavan, CGO Complex,
Lodi Road, New Delhi - 110 003.
Dated the 7th December, 1988.

RESOLUTION

National Forest Policy, 1988

A.P. Forest Development Corporation Ltd.,

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ORGANISATION
PLANTATIONS
BEEDI LEAF TRADE
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ECO TOURISM

Eucalyptus

Eucalyptus Plantations

THE HINDU

JUST IN

15 6hrs Tamil Nadu farmers detained outside PM's residence

1 5mins Roger Federer wins record eighth Wimbledon title

2 43mins Cow vigila dog filters, a goat th more - top stories fo

MENU

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ANDHRA PRADESH

Casuarina plantations offer multiple benefits

Ravi P. Benjamin

VISAKHAPATNAM:,MAY 11, 2012 00:00 IST
UPDATED: JULY 11, 2016 16:04 IST

LAND USE / LAND COVER MAP

ANDHRA PRADESH

2011-12

N

0 45 90 180 Km

MAHARASHTRA
CHHATTISGARH
ODISHA
KARNATAKA
BAY OF BENGAL
TAMILNADU

Adilabad
Nizamabad
Karimnagar
Warangal
Medak
Khammam
Hyderabad
Rangareddi
Nalgonda
Mahbubnagar
Guntur
Krishna
West Godavari
East Godavari
Vishakhapatnam
Srikakulam
Vizianagaram
Prakasam
Kurnool
Anantapur
Cuddapah
Nellore
Chittoor

Classes	Classes
Built Up	**Grass / Grazing**
Urban	Grass/Grazing
Rural	**Barren / Waste Lands**
Mining	Salt Affected Land
Agricultural Land	Gullied/Ravinous Land
Crop Land	Scrub Land
Agricultural Plantation	Sandy Area
Fallow Land	Barren Rocky
Current Shifting Cultivation	Rann
Forest	**Wetlands / Water bodies**
Evergreen/ Semi Evergreen	Water bodies
Deciduous	Rivers/Streams/Canals
Forest Plantation	Inland Wetland
Scrub Forest	Coastal Wetland
Swamp/ Mangroves	**Snow and Glaciers**
	Snow/Glaciers

Location Map

International Boundary — Coast Line
State Boundary — Rail Line
District Boundary — Major Road

Data Source:

Resourcesat-2 LISS III satellite data of Kharif (October / November) 2011, Rabi (January / February / March) 2012 and Zaid (April / May) 2012, Existing LULC map of 2005-06, Ground truth data and land reports.

Coordination:

National Remote Sensing Centre,
Indian Space Research Organization,
Department of Space, Govt. of India
Balanagar, Hyderabad
Telangana, India 500 037

nrsc

Partner Institution:

AP State Remote Sensing Centre (APSRAC),
HMDA Swarna Jayanthi Complex,
B Block, 8th Floor
Ameerpet, Hyderabad-5000 016

Adilabad
CHHATTISGARH
ODISHA
Srikakulam
Vizianagaram
Nizamabad
Karimnagar
Warangal
Medak
Vishakhapatnam
Khammam
East Godavari
Hyderabad
Rangareddi
Nalgonda
West Godavari
East Godavari
Krishna
Krishna
Mahbubnagar
Guntur
Prakasam
Kurnool
Anantapur
Cuddapah
Nellore
Chittoor
TAMILNADU
KARNATAKA
BAY OF BENGAL

Classes

Built Up

- Urban
- Rural
- Mining

Agricultural Land

- Crop Land
- Agricultural Plantation
- Fallow Land
- Current Shifting Cultivation

Forest

- Evergreen/ Semi Evergreen
- Deciduous
- Forest Plantation
- Scrub Forest
- Swamp/ Mangroves

Location Map

Coordination:

National Remote Sensing Centre,
Indian Space Research Organization,
Department of Space, Govt. of India
Balanagar, Hyderabad
Telangana, India 500 037

Economic Analysis

Determine incentives for forest processing firms to establish plantation agreements with farmers – phase 1 (year 1)

→ What is the value to firms from these agreements?
→ Do these agreements improve economic efficiency?

Determine incentives for farmers to adopt forest plantations – Phase 2 (year 2)

→ What payment will farmers accept to adopt plantations for household production?
→ What characteristics of farmers, costs, and market opportunities drive plantation adoption?

Integrate farmer/firm decision models into land use change predictions – phase 3 (year 3)

Plantation Wood Value

- Value marginal product: additional value of production from an additional ton of wood from plantations

$$\rightarrow VMP_i = \frac{d\gamma_{Fi} f_i(T_F, \psi_F, S; \widehat{\beta})}{d\psi_F}$$

- Economic efficiency: can the firm produce more for any given input?

→ comparison of estimated γ_{Fi} for firms with and without plantation agreements

Andhra Pradesh Mills

Categorical variable	Number of firms	Proportion of observations (%)
Rural location	638	51.17
Urban location	638	48.36
Privately-owned	463	42.76
Individual proprietorship	463	17.71
Government-owned	463	57.24
Not ISO 1400 certified	127	91.34
ISO 1400 certified	127	8.66

Plantation Wood Importance

- Production function for firm *i* (y_{Fi} = value of production at time *t)*

$$y_{Fi} = \gamma_{Fi} f_i(T_F, \psi_F, S; \varepsilon_i, \beta)$$

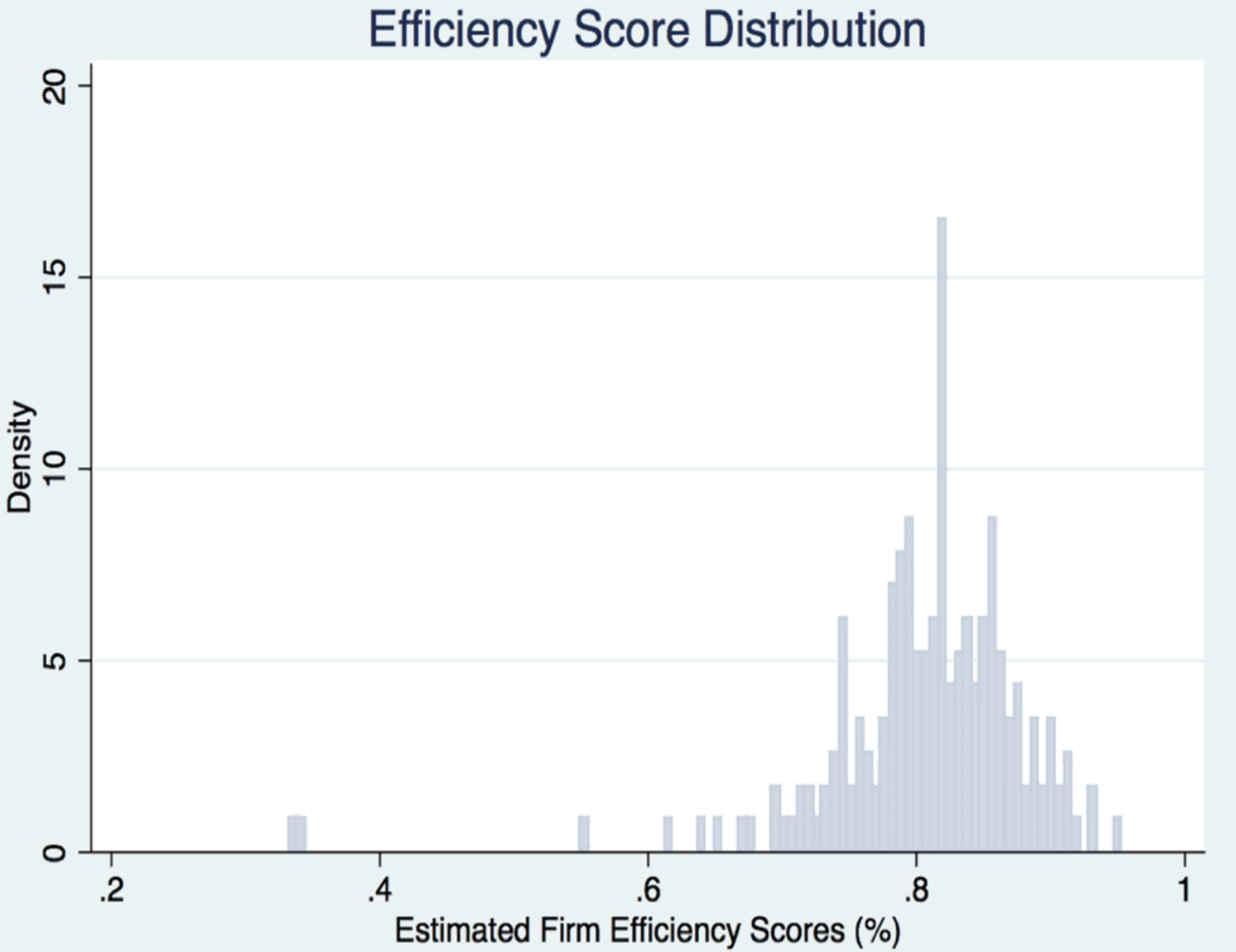
γ_{Fi}	efficiency score parameter (1 = perfect efficiency)
T_F	labor input
ψ_F	wood input
S	other factors important to production
ε_i	stochastic error
β	coefficients to estimate

- Production function is estimated with firm level data on inputs and outputs, using stochastic frontier methods in econometrics

Stochastic Production Frontier Estimation Results						
Log likelihood	-32.241898		N. Observations =		187	
Wald chi2(5) =	11133.680		Prob > chi2 =		0.000	
Dependent variable: ln(gross value of outputs)	**Coefficient**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**	**Interval]**
Independent variables:						
ln(value of fuel)	0.118	0.023	5.17	0.000	0.073	0.163
ln(value of materials)	0.622	0.036	17.13	0.000	0.550	0.693
ln(total value of salaries)	0.114	0.039	2.93	0.003	0.038	0.190
ln(value of working capital)	0.074	0.020	3.78	0.000	0.036	0.112
ln(gross value of fixed capital)	0.116	0.035	3.27	0.001	0.046	0.185
Constant	0.727	0.249	2.92	0.004	0.239	1.216
Error terms:	**Coefficient**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
sigma_u_sqr	0.086	0.030	2.82	0.005	0.043	0.172
sigma_v_sqr	0.053	0.011	4.99	0.000	0.036	0.078
Likelihood ratio test	6.3456					

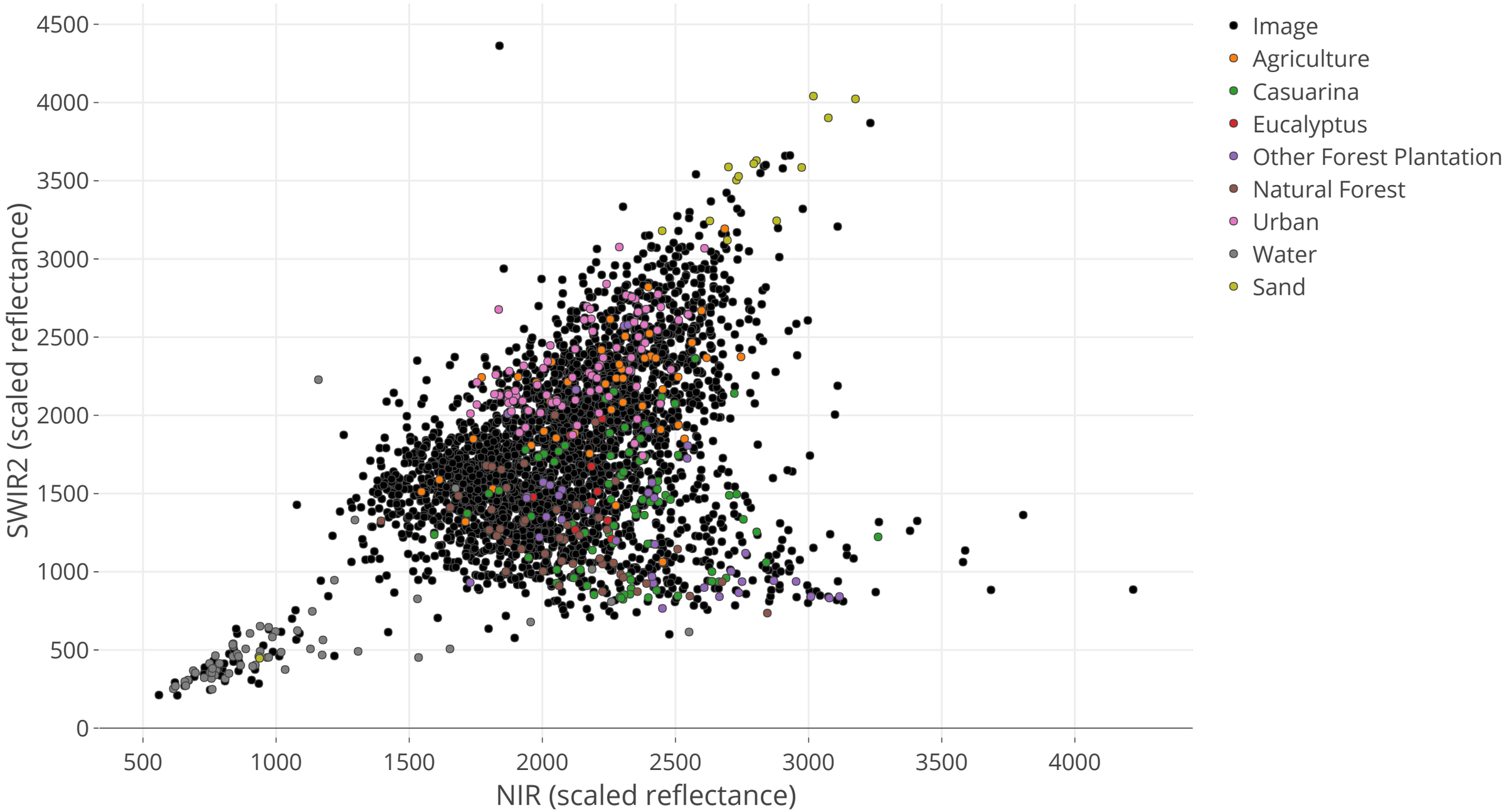
Stochastic Production Frontier Estimation

Materials = > 90% Wood Inputs


Efficiency Score Distribution
Density
0
5
10
15
20
.2
.4
.6
.8
1
Estimated Firm Efficiency Scores (%)

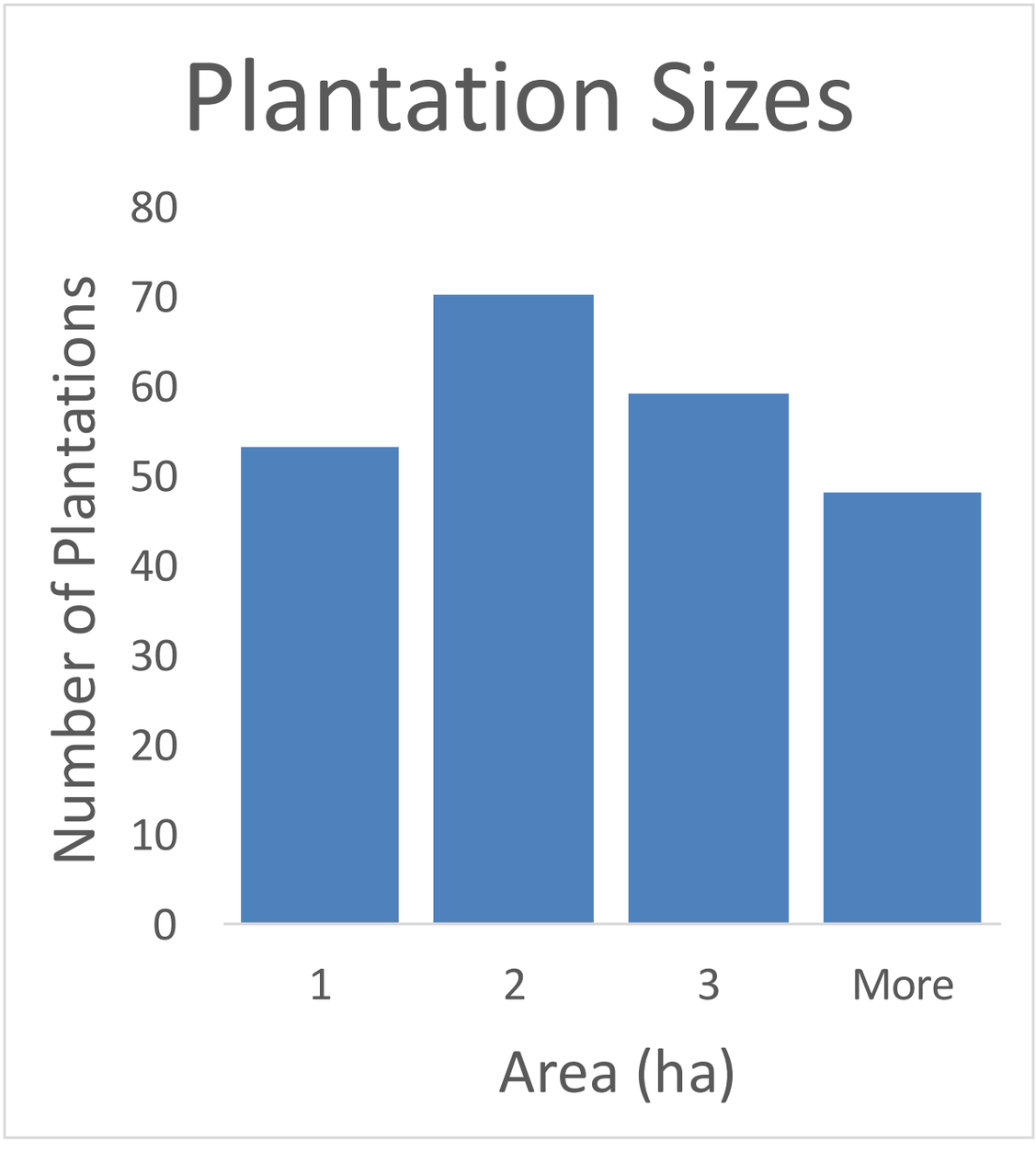
Economic Analysis Phase I Results

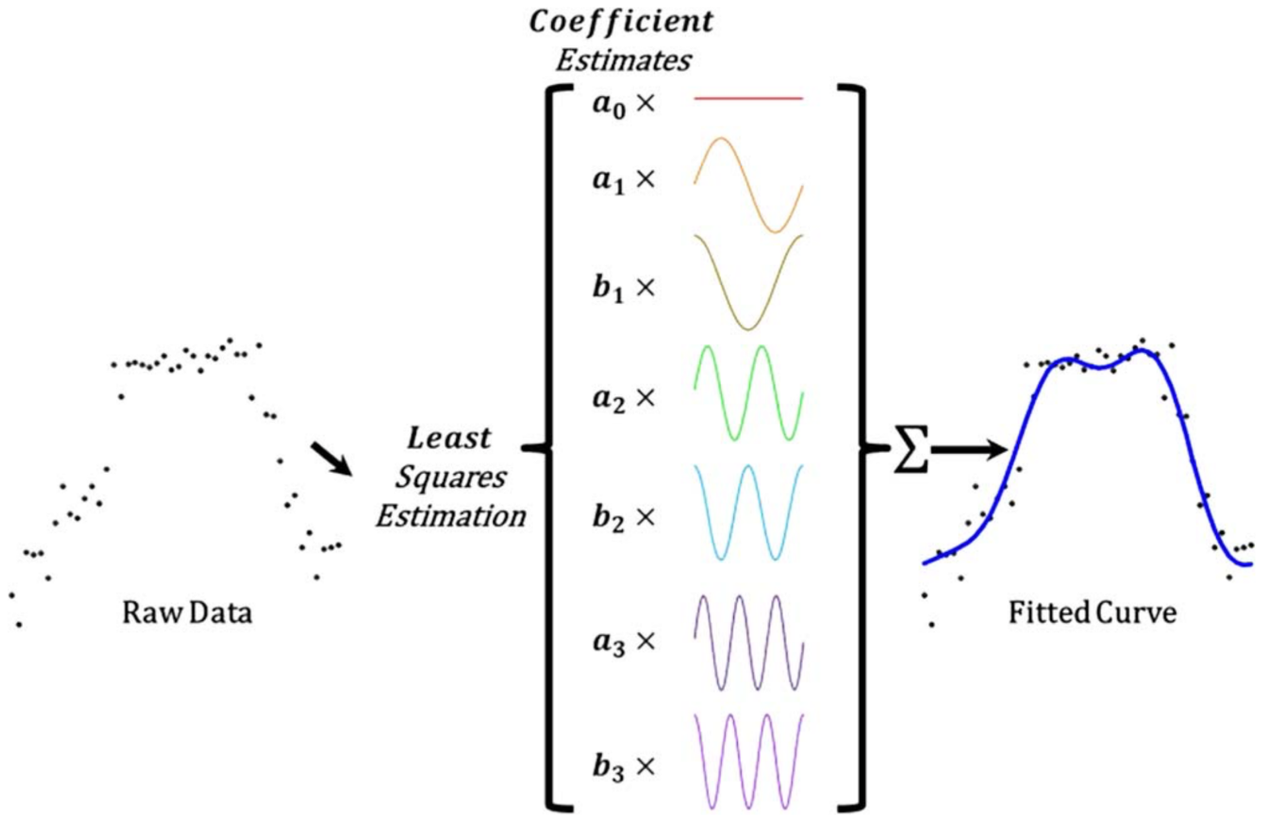
- We have estimated a prediction equation for firm level willingness to pay for wood as function of inputs (value marginal product function)
- We find wood to be the most statistically significant and important input to production for Andhra Pradesh forest product firms
- On average, each additional $R of wood increases the value of production by 0.62 $R ($Rs = 0.015 USD)
- Firms on average are operating at about 75-85% of the theoretically efficient level (γ_{Fi}, efficiency score parameter, = 1)
- Question still to evaluate is whether firms with plantation agreements have higher efficiency scores than firms without

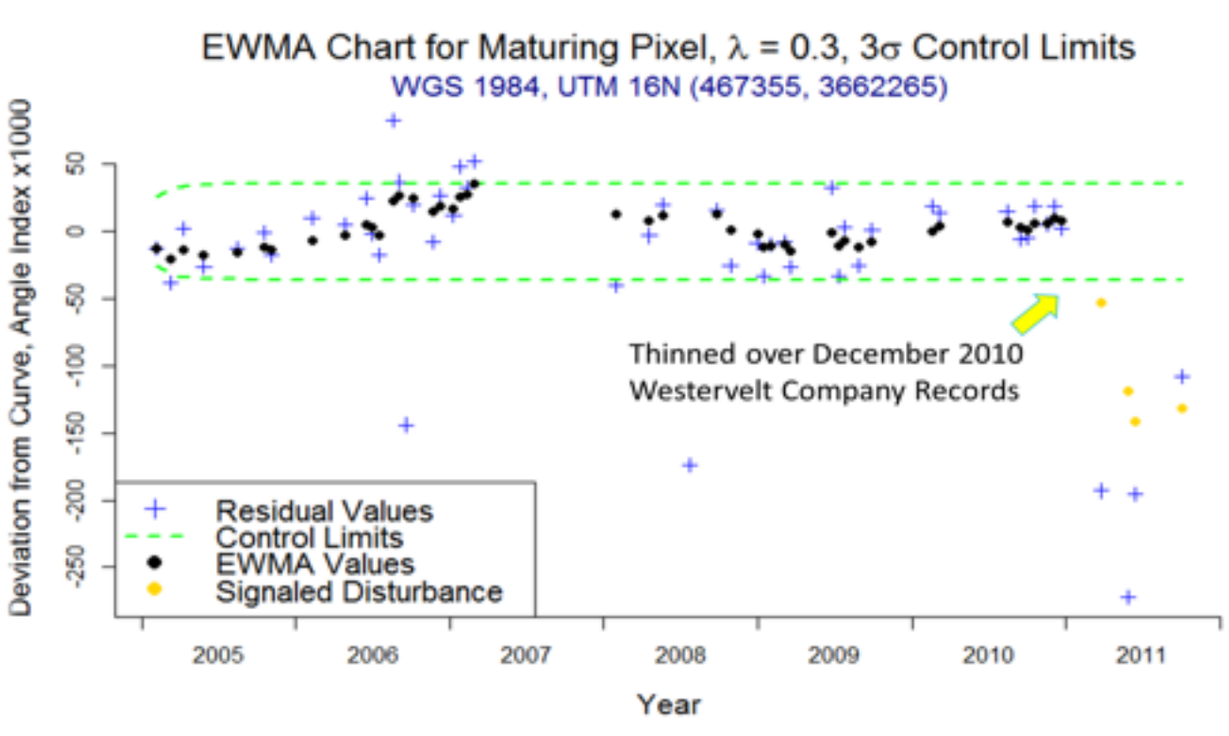

4500
4000
3500
3000
2500
2000
1500
1000
500
0
SWIR2 (scaled reflectance)
500
1000
1500
2000
2500
3000
3500
4000
NIR (scaled reflectance)
Image
Agriculture
Casuarina
Eucalyptus
Other Forest Plantation
Natural Forest
Urban
Water
Sand

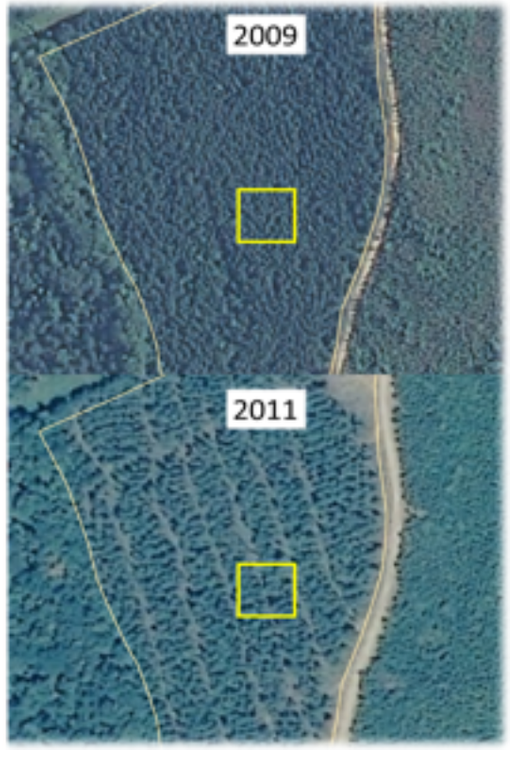
Small!

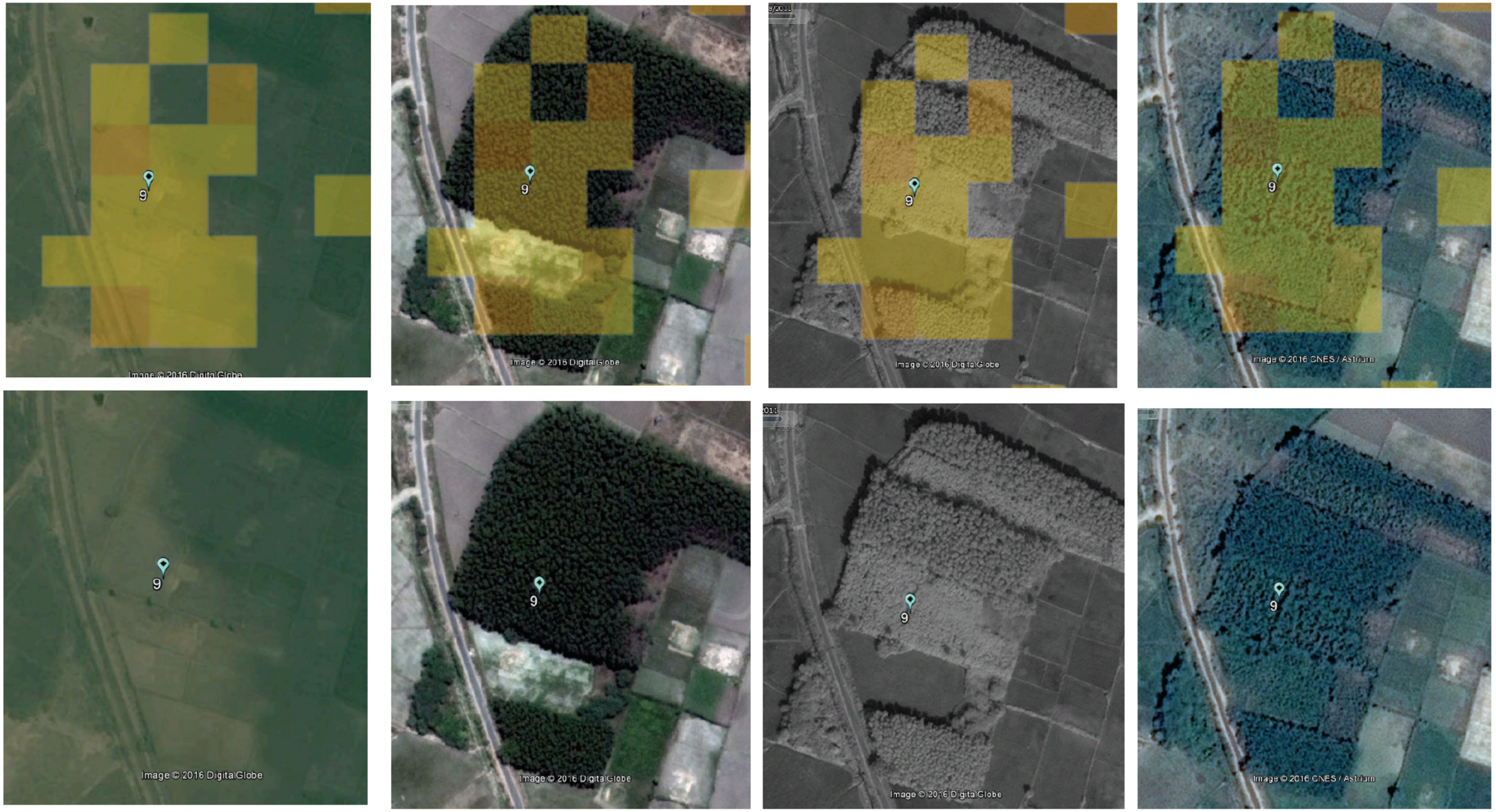
n	230
Min	0.4
Max	9.7
Mean	2.1
First Quartile	1.0
Median	1.8
Third Quartile	2.6
Standard Deviation	1.4
Variance	2.1
Standard Error	0.1




Coefficient Estimates
$a_0 \times$
$a_1 \times$
$b_1 \times$
$a_2 \times$
$b_2 \times$
$a_3 \times$
$b_3 \times$
Least Squares Estimation
Raw Data
Σ
Fitted Curve


EWMA Chart for Maturing Pixel, λ = 0.3, 3σ Control Limits
WGS 1984, UTM 16N (467355, 3662265)
Deviation from Curve, Angle Index x1000
50
0
-50
-100
-150
-200
-250
Thinned over December 2010
Westervelt Company Records
Residual Values
Control Limits
EWMA Values
Signaled Disturbance
2005
2006
2007
2008
2009
2010
2011
Year


2009
2011



Example of harmonic coefficient-based classification of a forest plantation in Andhra Pradesh. 166 Landsat 7 and 8 images from path 143 row 49 spanning from 2000 to 2016 were used in this analysis. Results shown used SWIR2. Note that while the plantation is identified that there are remnant issues with both omission and commission errors.

Casuarina

Casuarina in East Godavari

2 landowners

31 Dec 2006

27 Feb 2011

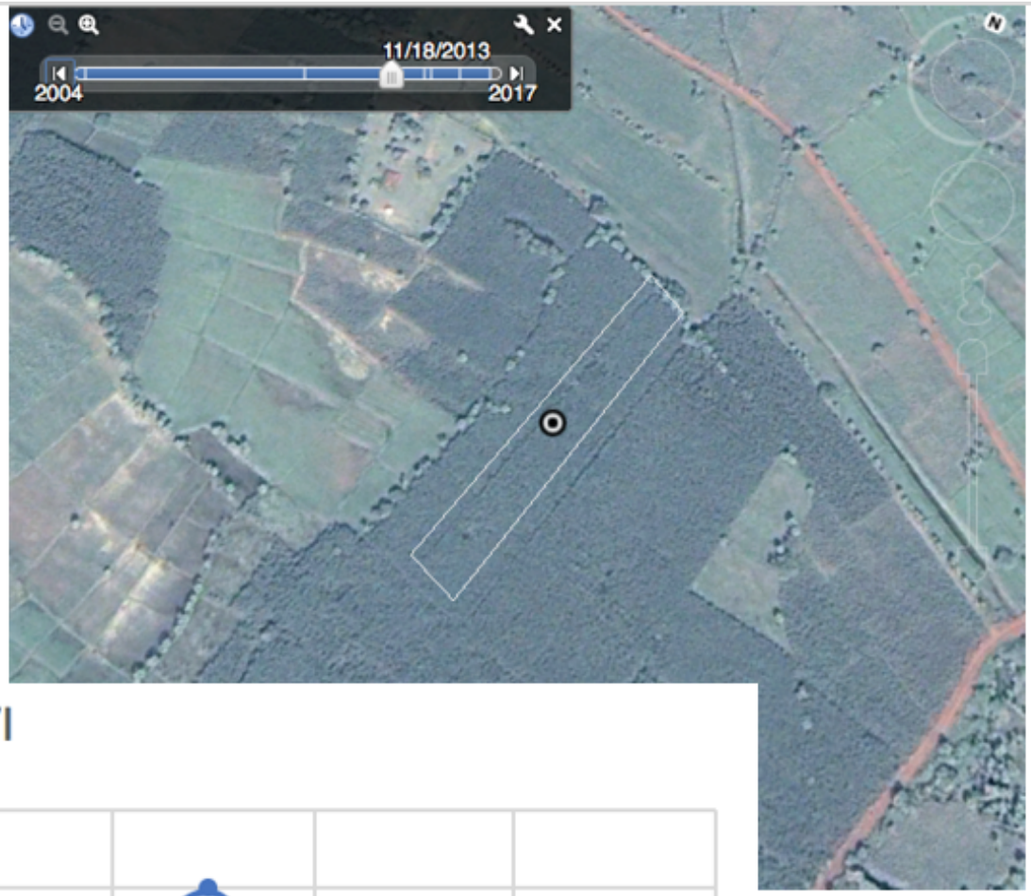
18 Nov 2013

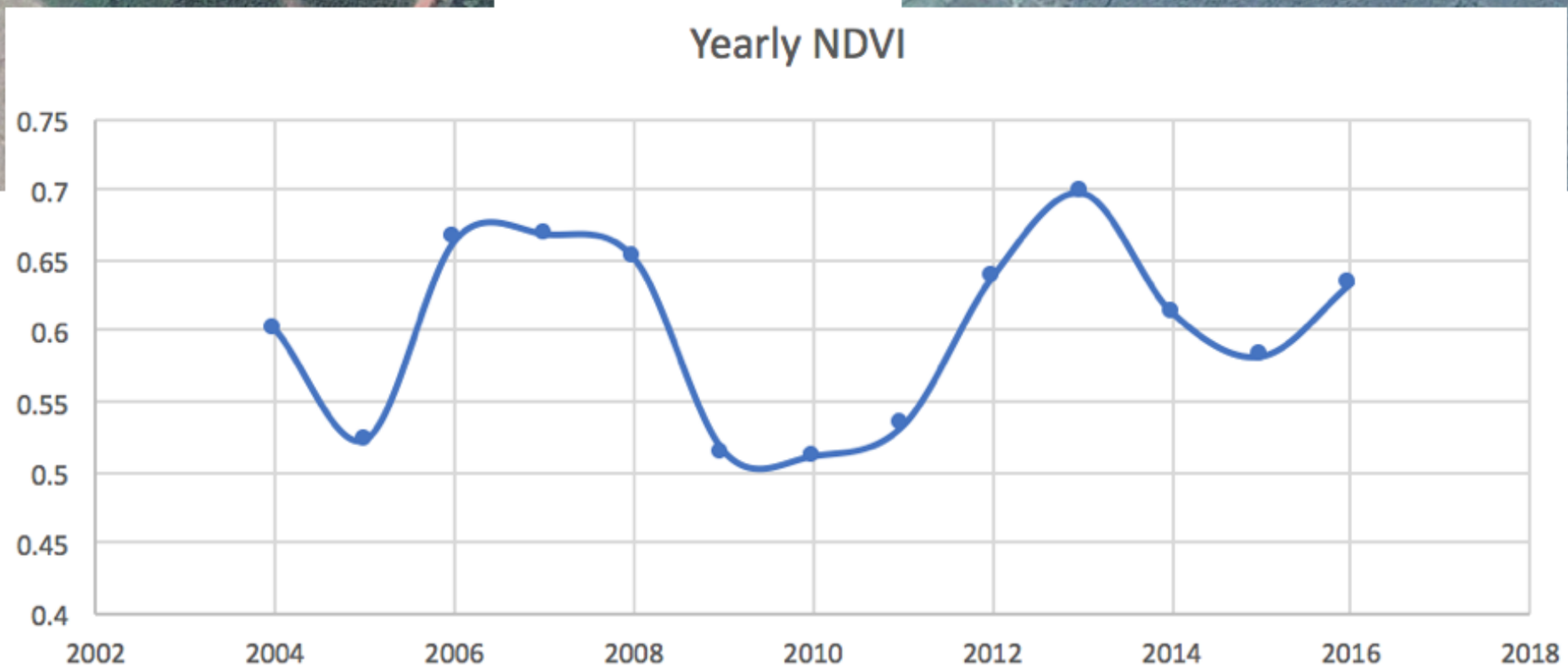
20 Dec 2014

12 Mar 2015

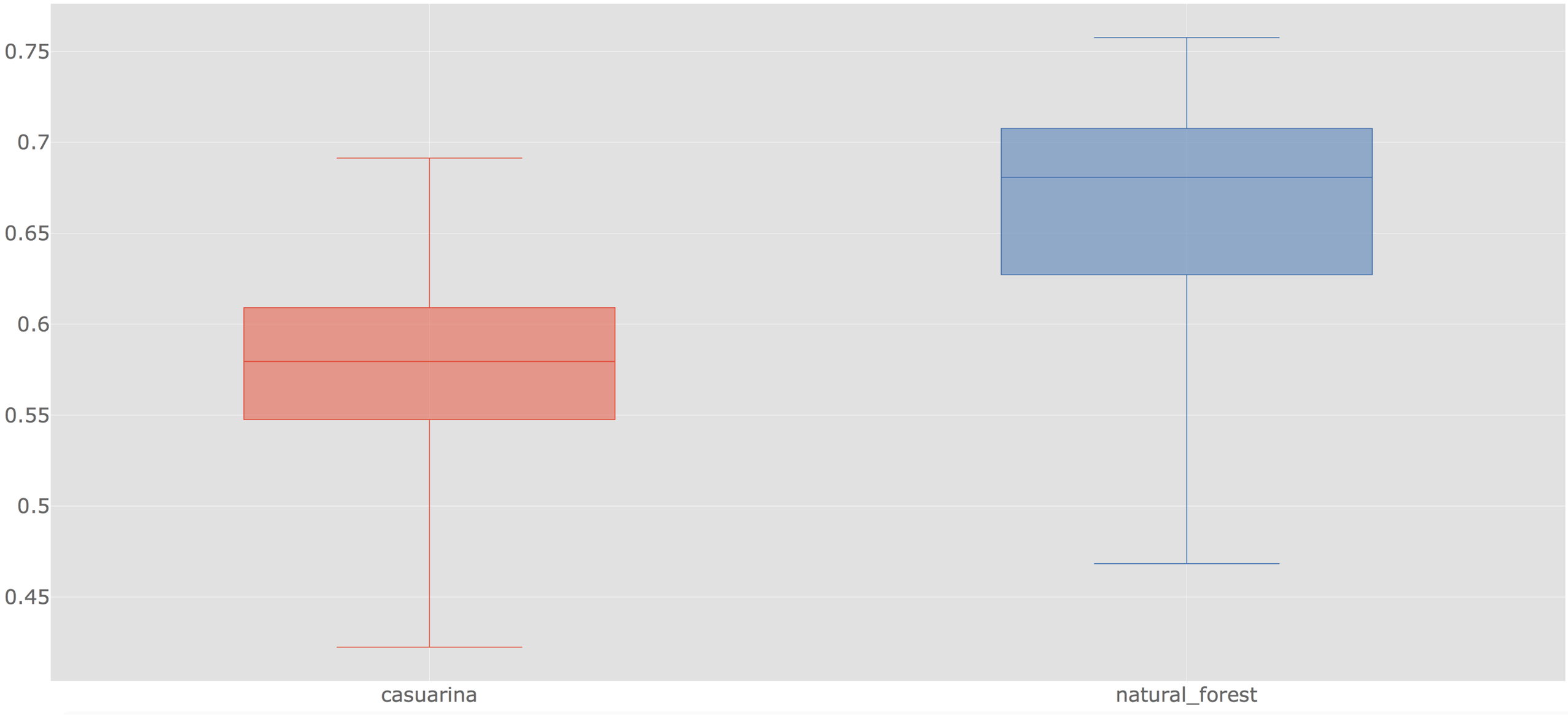
19 Feb 2016


2/27/2011
2004
2017

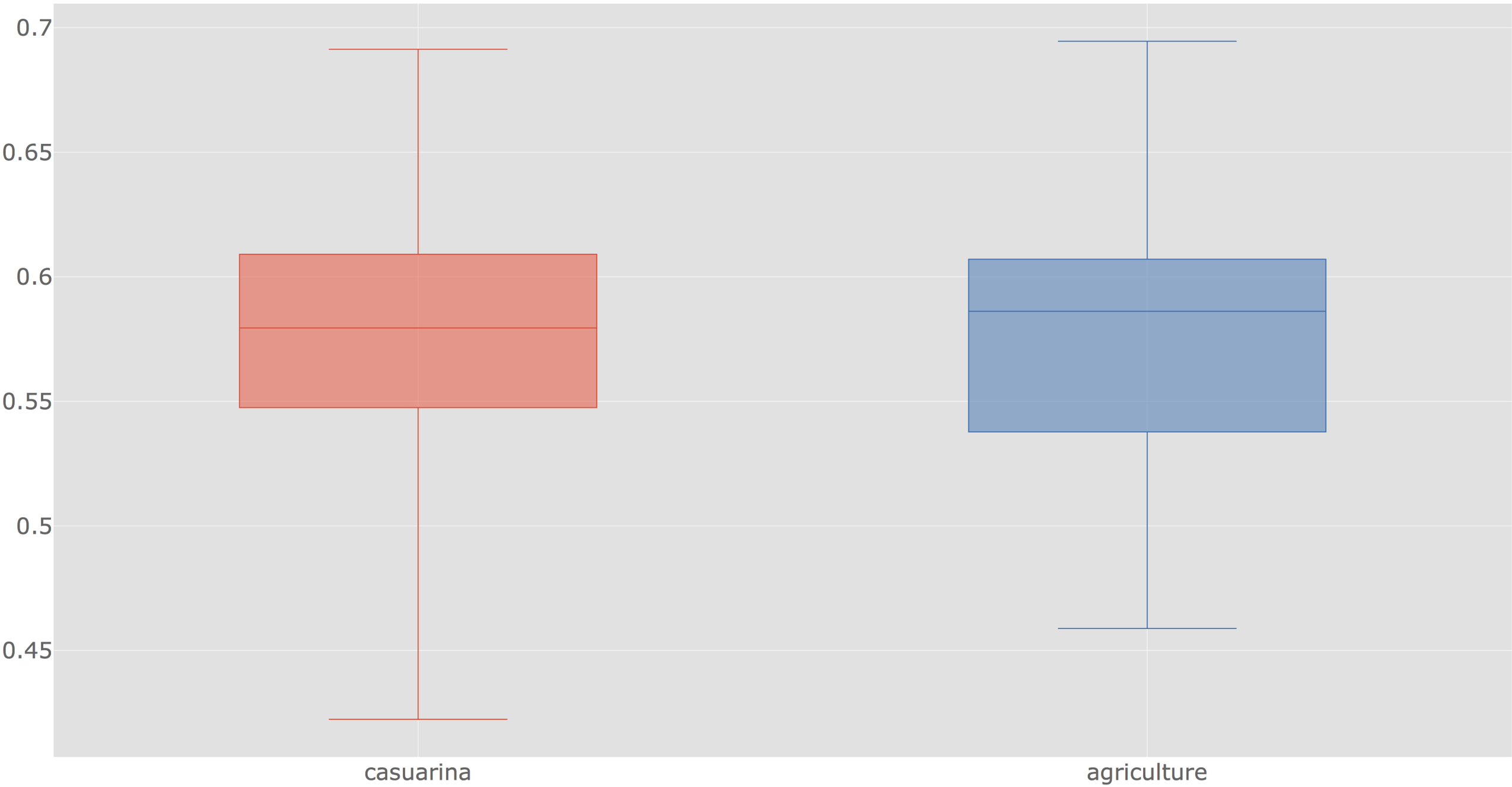

11/18/2013
2004
2017


Yearly NDVI
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
2002
2004
2006
2008
2010
2012
2014
2016
2018

Means of Annual Greenness Maxima: Natural Forest vs. Planted Casuarina



Means of Annual Greenness Maxima: Planted Casuarina vs. Agriculture



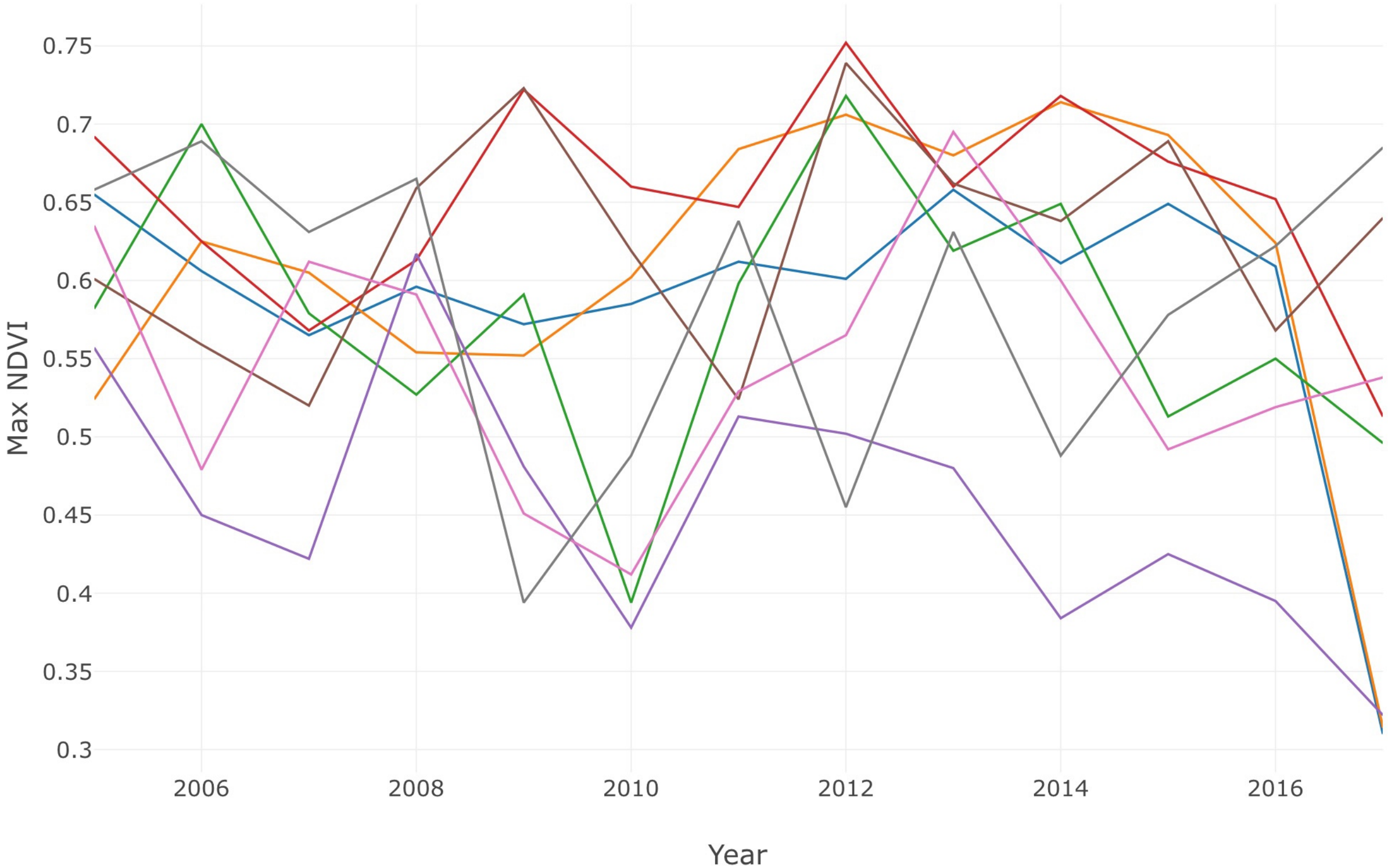
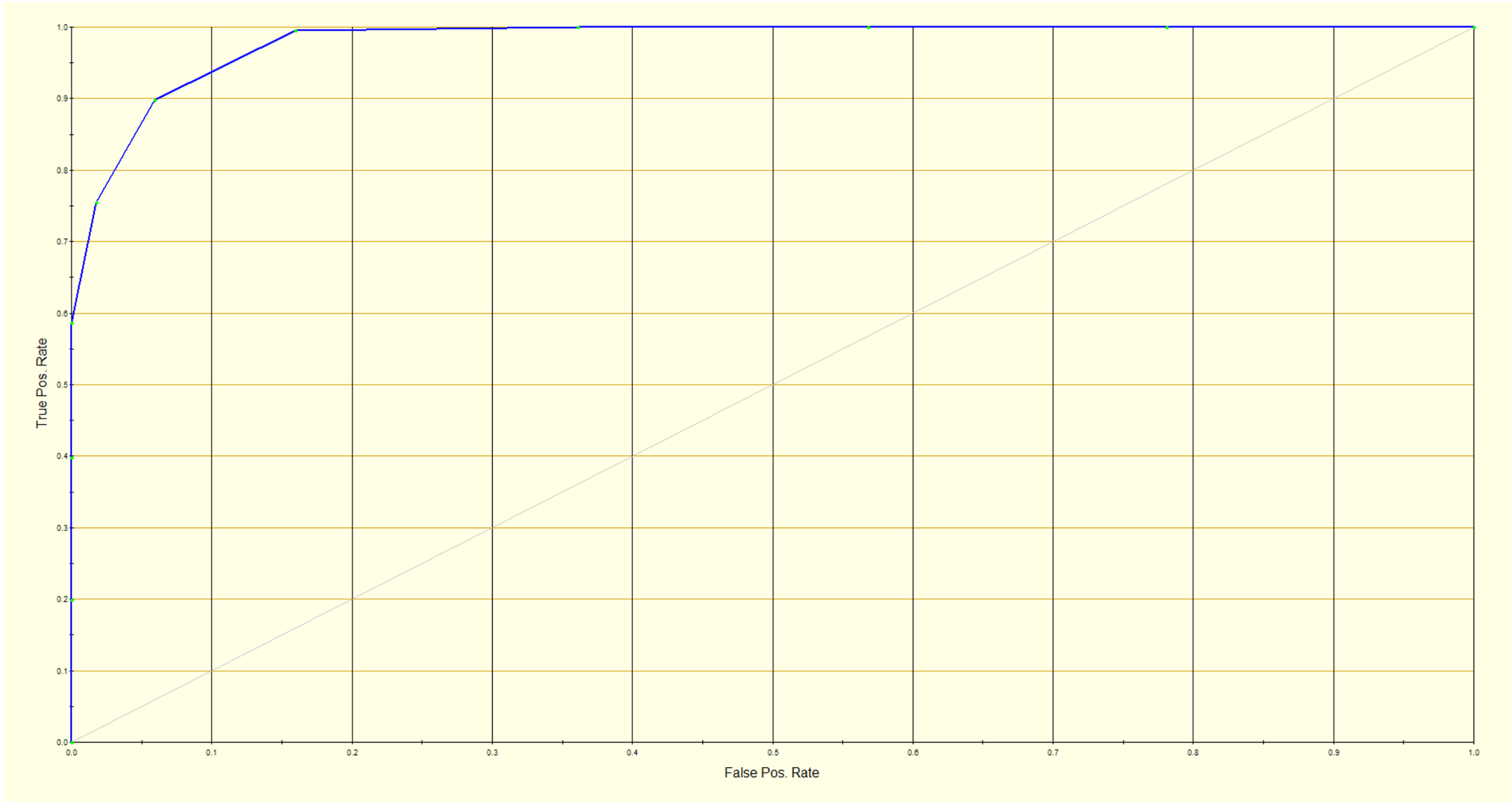
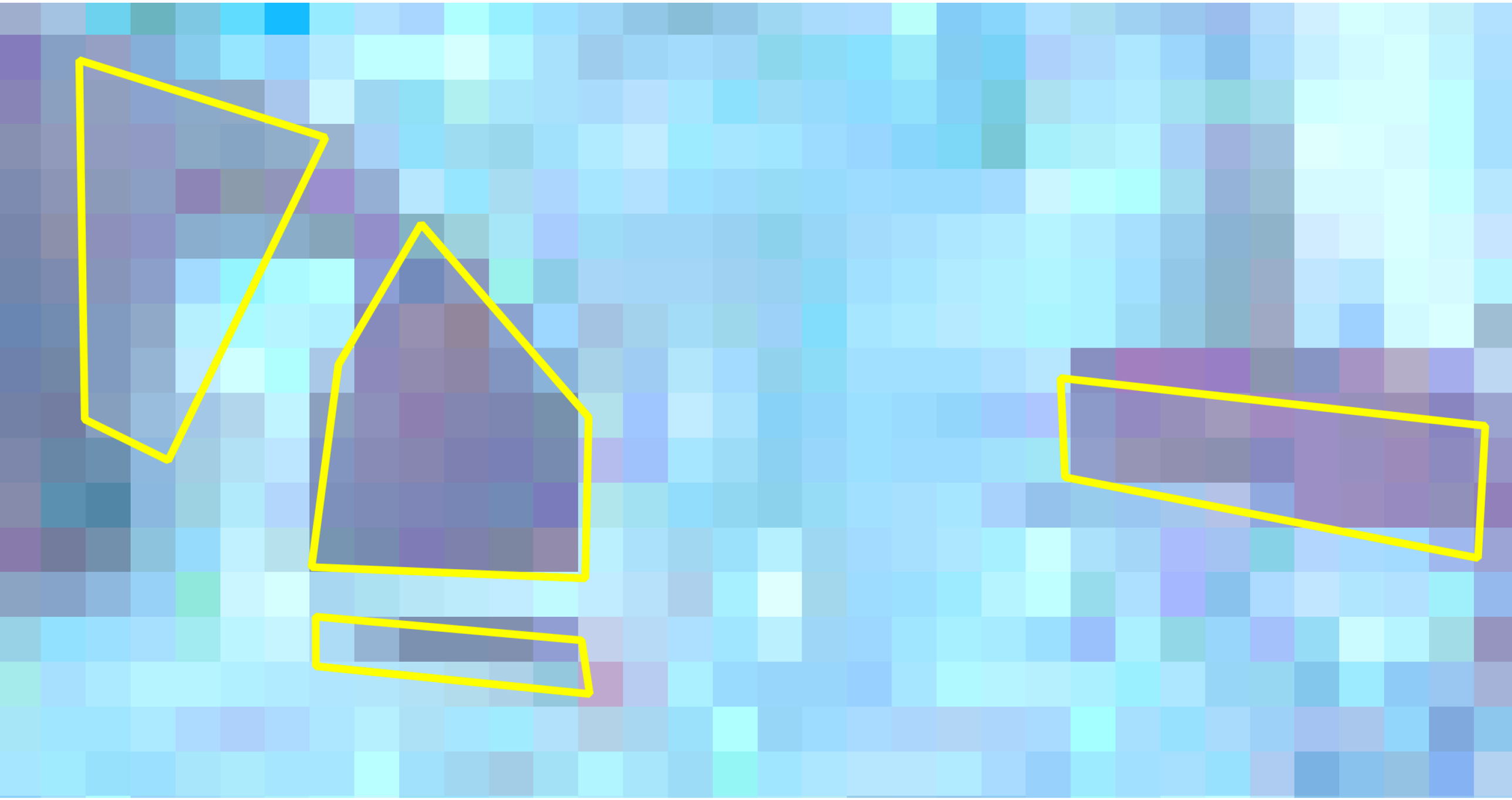
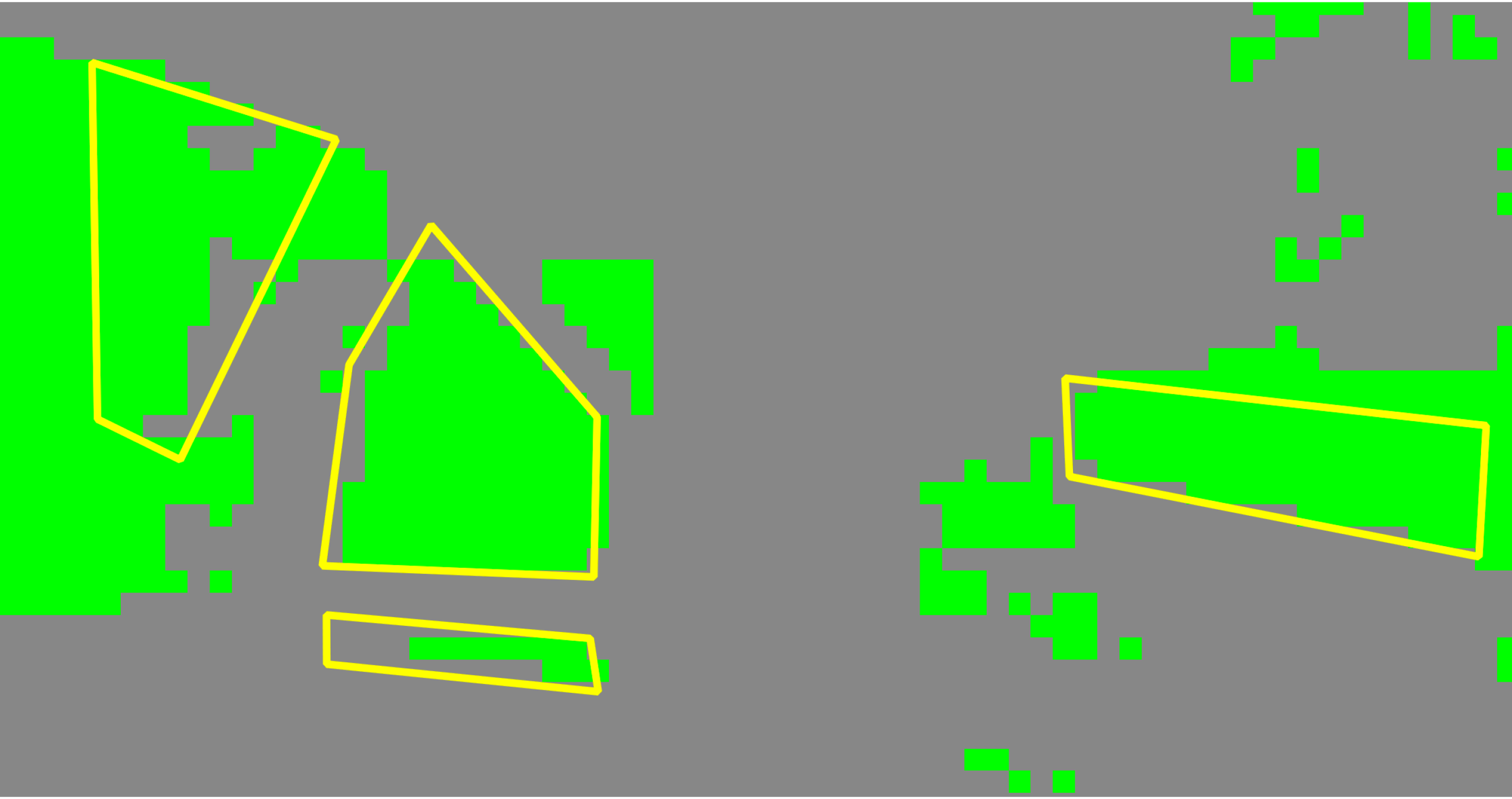

0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
Max NDVI
2006
2008
2010
2012
2014
2016
Year

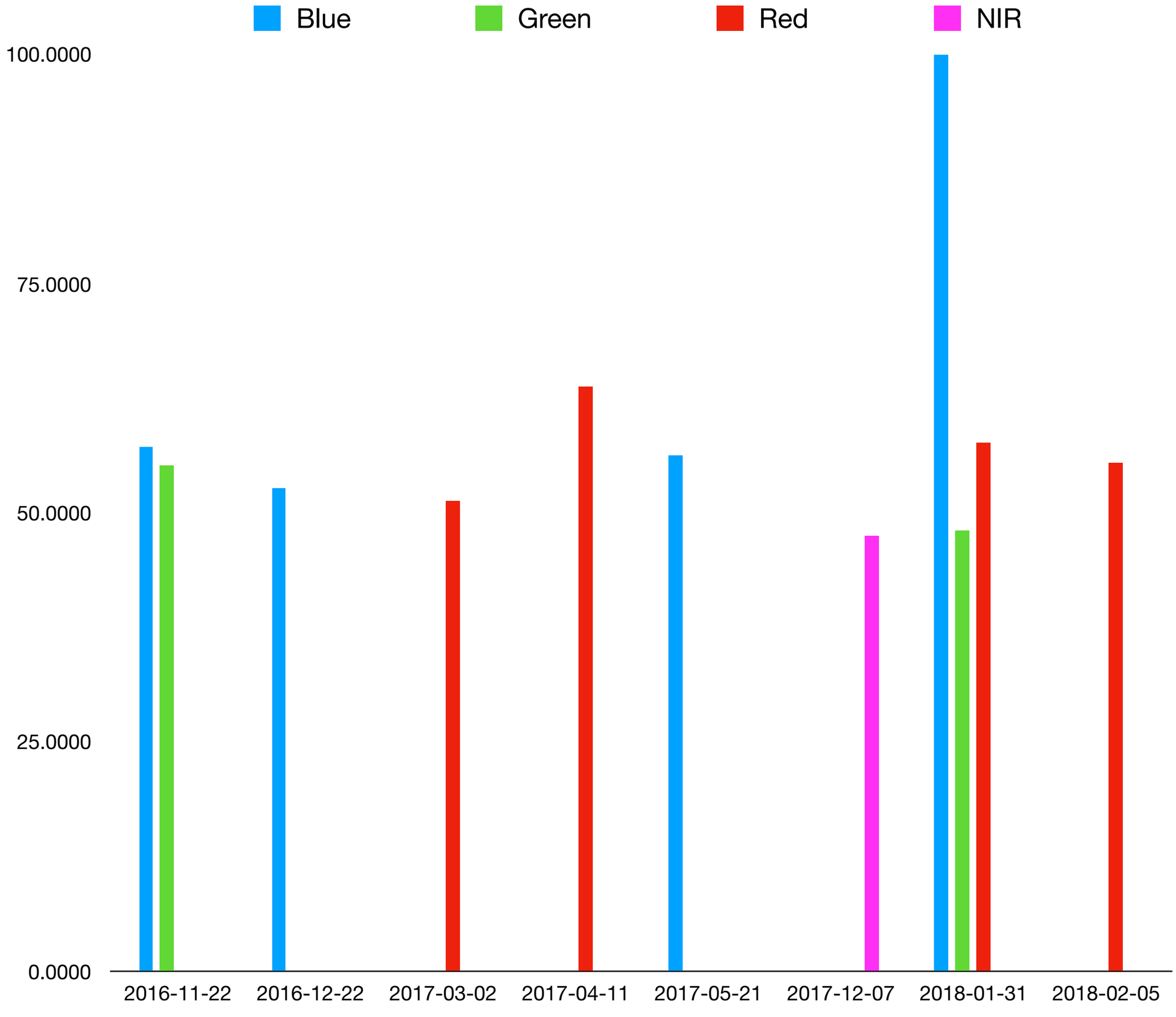
Table 2: Error matrix from pilot Sentinel 2 classification.

Actual Class	Natural Forest N = 54	Nonforest N = 170	Plantation N = 141
Natural Forest	38	0	8
Nonforest	3	166	27
Plantation	13	4	106








Blue
Green
Red
NIR
100.0000
75.0000
50.0000
25.0000
0.0000
2016-11-22
2016-12-22
2017-03-02
2017-04-11
2017-05-21
2017-12-07
2018-01-31
2018-02-05

Downsides

- Food security?
- Water use (trees and mills) and water quality (mills)
- Even-aged monocultures

Upsides

- Carbon accounting slightly positive (preliminarily)
- Potential decrease in radiative forcing
- Improved local and national economies
- Uptick in other forest-based ecosystem services
- Smallholder land tenure

Conclusions

- Plantation forestry rapidly expanding in Asia
- Small spatial extent and rapid harvest-regeneration cycle present interesting — but resolvable — remote sensing challenges
- Understanding the drivers and ramifications of these new trees outside forests vital