A prototype monitoring system compliant with IPCC *Approach 3* for securing activity data: application to the Colombian Amazon

Funded by SilvaCarbon

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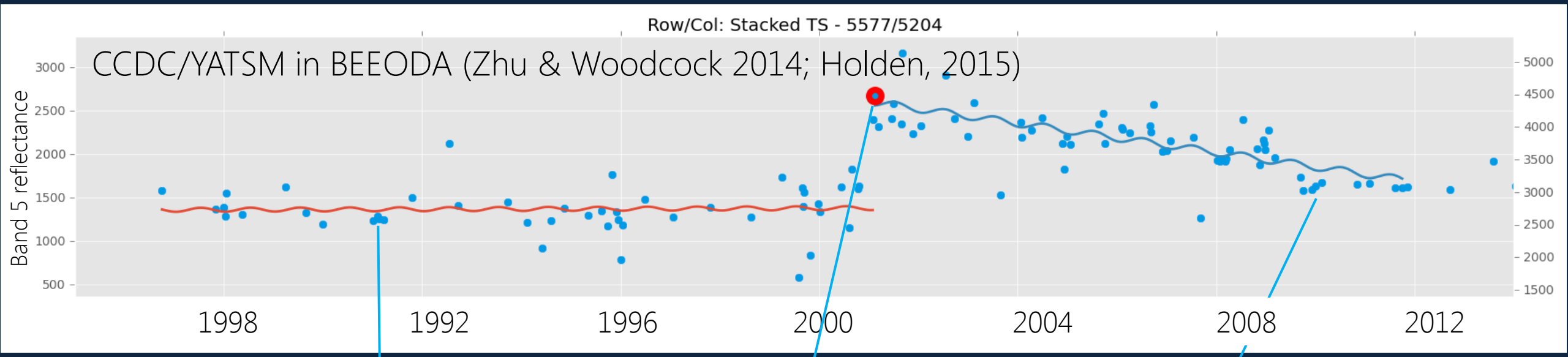
Washington DC,
Sept. 29, 2016

Background and objectives

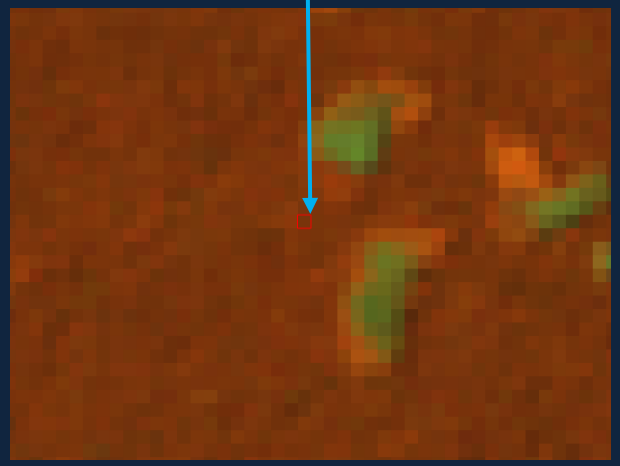
- Activity data required for gain/loss approach for REDD+ reporting
- IPCC Approach 3: Spatial/temporal explicit estimates of activity data
- Approach 3 enables Tier 3 reporting
- Prototype implemented in BEEODA, fully open source (GitHub)

Objective: *Obtain annual unbiased estimates of areas of IPCC land categories and conversions with 95% CIs for the Colombian Amazon from 2000 and onwards*

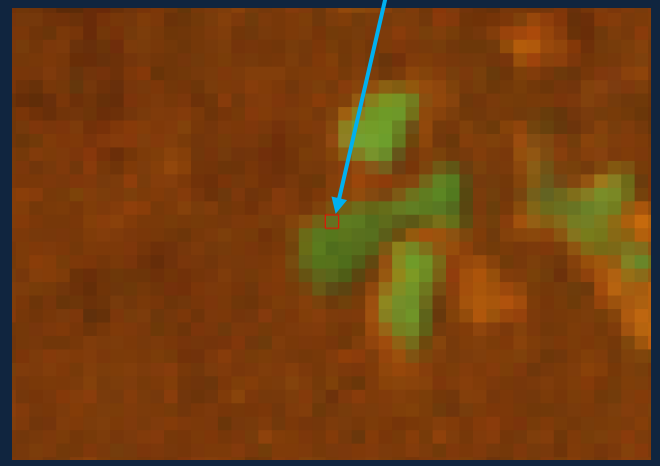
Methods



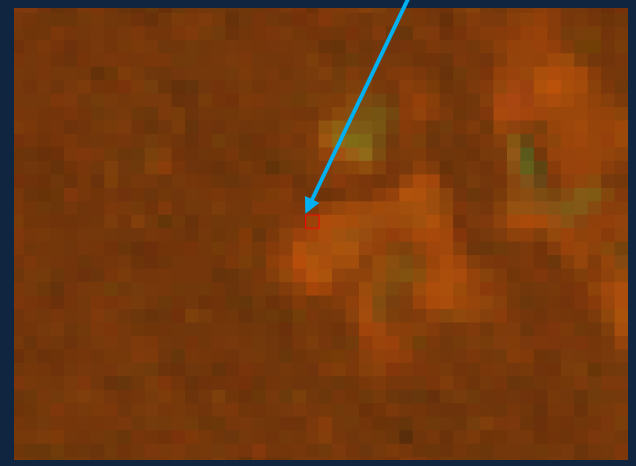
RGB
453



1991



2001



2011

Workflow overview

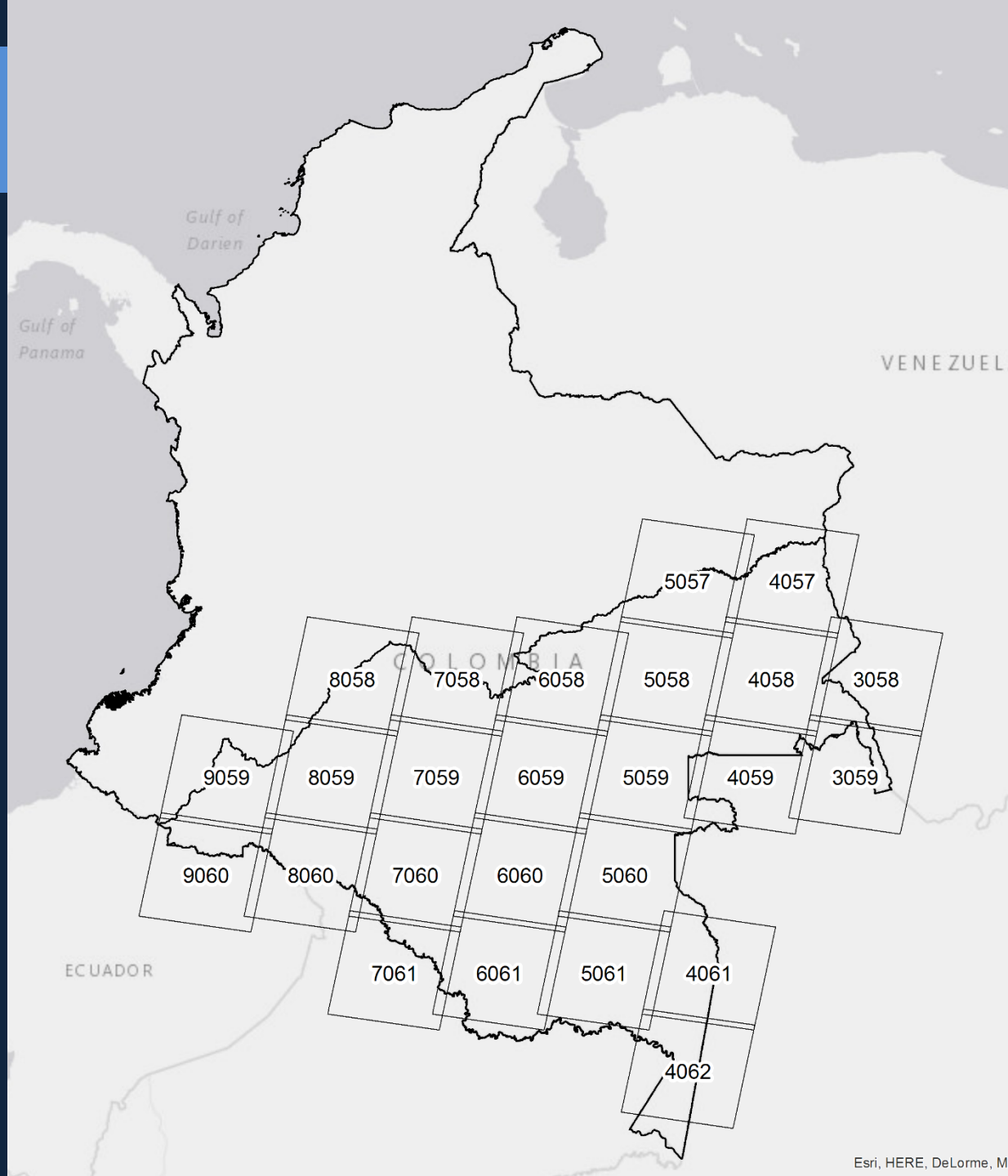
1) Data pre-processing

2) Model runs

3) Classification and mapping

4) Post-processing and mosaicking

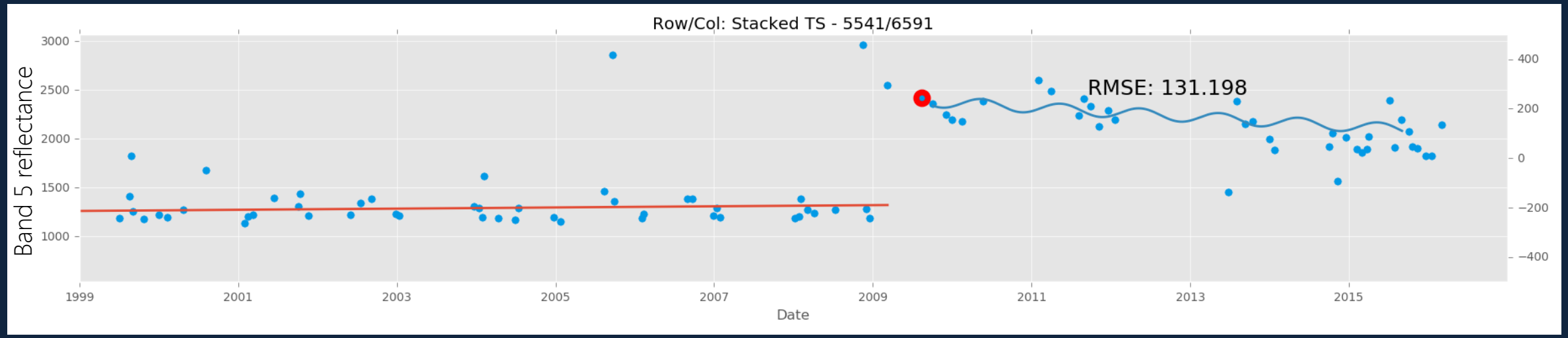
5) Area estimation



Area estimation

- Stratified estimation, 14 strata, 1050 sample units
- “Continuous reference labels” collected
- Continuous map and reference labels allows for continuous area estimation – unbiased annual estimates computed following Stehman (2014)
- Scripts in BEEODA on GitHub

Example:



MAP	F	F	F	F	F	F	F	F	F	F	FP	FP	FP	FP	FP	FP	FP
REF.	F	F	F	F	F	F	F	F	F	FP	FP	FP	FP	FP	FP	FP	FP

F: FOREST

FP: FOREST TO PASTURE

FROM

TO

	1	2	3	4	5	6	7
1	1	0	0	0	5	0	0
2	0	2	0	0	14	0	0
3	0	0	3	0	14	0	0
4	8	0	0	4	14	0	0
5	9	11	11	11	5	11	11
6	0	0	0	0	14	6	0
7	0	0	0	0	14	0	3
Unclass	8	13	13	13	14	13	13

STABLE CLASSES

1. Forest
2. Grassland
3. Urban + "other"
4. Pasture/cropland
5. Secondary forest
6. Water
7. [merged]

CHANGE CLASSES

8. Forest to pastures/unclass.
9. Forest to secondary forest
10. [merged]
11. Gain of secondary forest
12. All to unclassified
13. Loss of secondary forest

0. All others to all others

Applications Places System 22 °C Mon Jun 13, 18:32

QGIS 2.6.1-Brighton - Sample_collection_WEST (on scc-pi3)

Project Edit View Layer Settings Plugins Vector Raster Database Web Processing Help

Layers

- Query
- sample_west_UTM18N_ID_PR_ZONE
- scene_overlap
- WRS2_amazon_selection
- LE70070582015341EDC00
- LE70070582014354EDC00
- LE70070582002065EDC00
- LE70070582001030AGS00

TSTools Controls

Options | Symbology | Images | Plot

Click to Add Points from Plot

Band Options

Band: ----- Select Plot Band -----

Y-Axis

Axis 1 Axis 2

Auto-scale

Min: 632.52

Max: 3728.08

Date Range

1997

2016

Fixed date range

Plot Features

Fmask: 2, 3, 4, 255

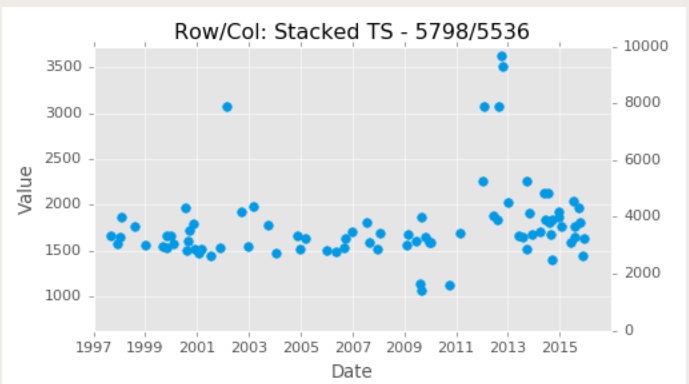
Model Fit Break Points

Driver specific

Symbology

TSTools Plots

Timeseries Plot | Stacked Day of Year Plot | Residual Plot



Attribute table - sample_west_UTM18N_ID_PR_ZONE :: Features total: 533, filtered: 16, selected: 1

ID = ε Update Filtered

		ROW	COL	R	ZONE	UMCHANGE	CODE1	CLASS1	CODE2	CLASS2	CODE3	CLASS3	CODE4	CLASS4	CONFIDENC	NOTES	CHGDATE
508	9	8639	15224	758	UTM18N	0	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	2	Looks like forest but has few points and high refl	NULL
493	5	10737	18876	758	UTM18N	1	1	Forest	5	Regrowth	5	Regr...	NULL	NULL	1	Very challenging, 1st looks like regrowth too	2002-03, 2012-01
489	1	8347	15349	758	UTM18N	1	4	Pasture	5	Regrowth	NULL	NULL	NULL	NULL	2	Significant gap would make fitting a model diffic.	2010-01
386	0	9444	18483	758	UTM18N	1	7	Other	6	Water	NULL	NULL	NULL	NULL	2	Mixe of sand/forest to water	2002-12
176	1	10492	15378	758	UTM18N	0	1	Forest	NULL	NULL	NULL	NULL	NULL	NULL	2	True forest with HUGE data gap 03-07	NULL
180	6	21245	15939	760	UTM18N	0	6	Water	NULL	NULL	NULL	NULL	NULL	NULL	2	Mostly water but could have been labeled as san...	NULL
82	7	11563	11756	858	UTM18N	1	1	Forest	5	Regrowth	NULL	NULL	NULL	NULL	2	Very hard to label, re check	?
30	2	9525	11227	858	UTM18N	0	4	Pasture	NULL	NULL	NULL	NULL	NULL	NULL	2	Looks like pasture but most likely river?	NULL
102	3	16561	9374	859	UTM18N	1	5	Regro...	4	Pasture	NULL	NULL	NULL	NULL	2	Super quick regrow after break, then pastures	2010-01?
75	4	14820	8832	859	UTM18N	1	4	Pasture	5	Regrowth	NULL	NULL	NULL	NULL	2	Maybe a third segm. w forest? Plantation?	2009-11

Advanced Filter (Expression) "CONFIDENCE" = 2 Apply

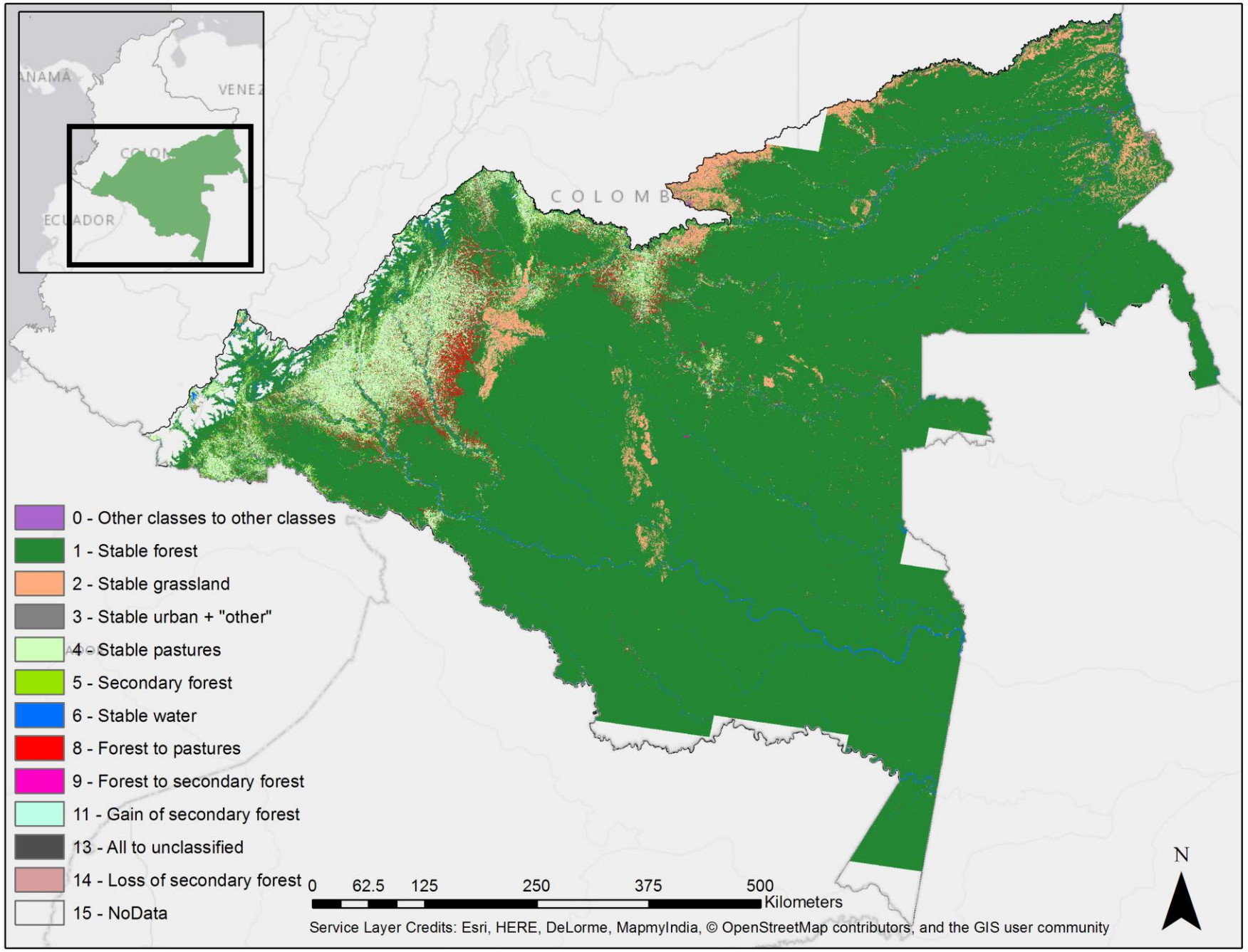
1 feature(s) selected on layer sample_west_UTM18N_ID_PR_ZONE.

Coordinate: 729947.7,272867.5 Scale 1:3,757 Render EPSG:32618

[12062016 - File Brow... | Terminal | parevalo@geo:/projec... | SGE Interactive Job 8... | QGIS 2.6.1-Brighton - ...

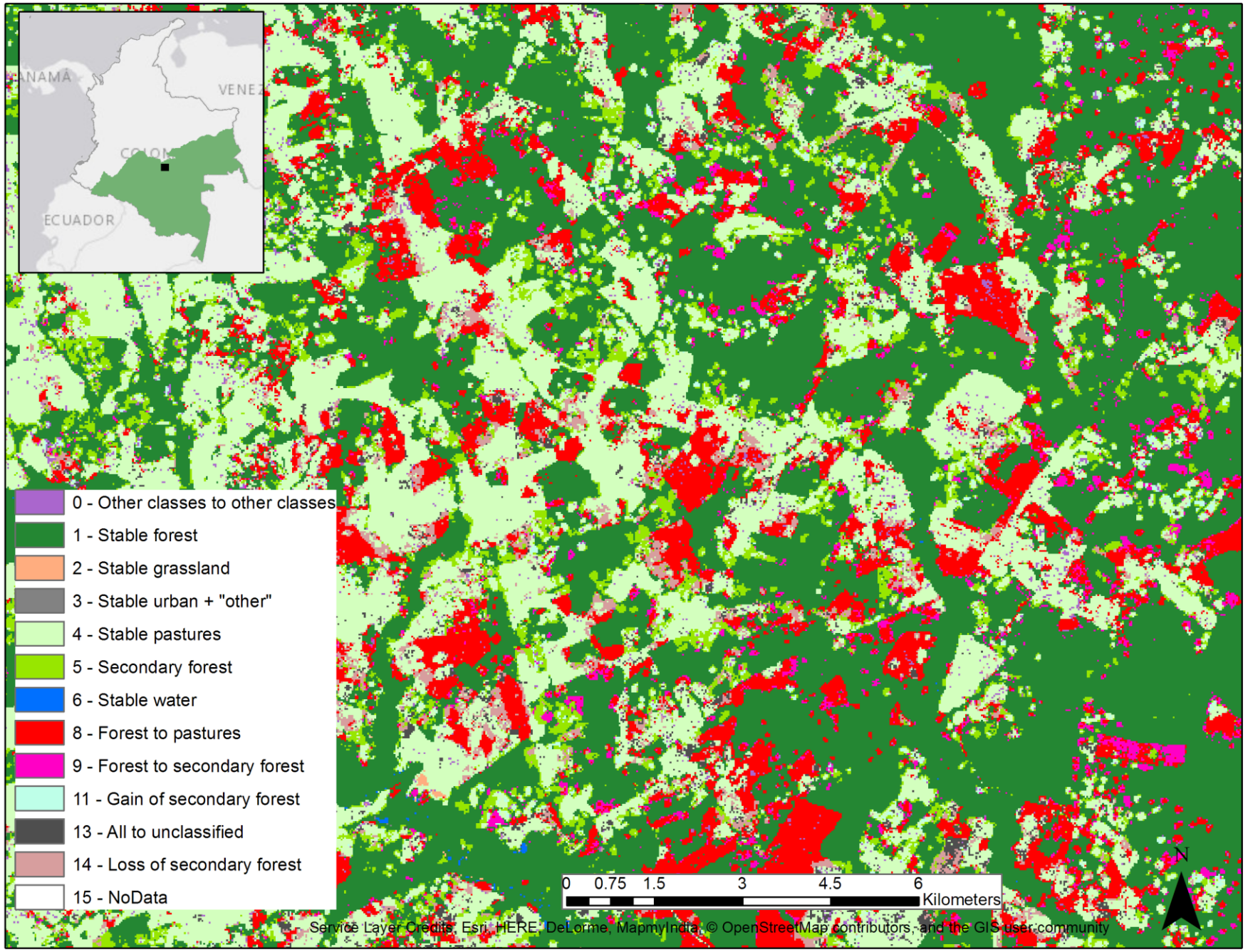
Results

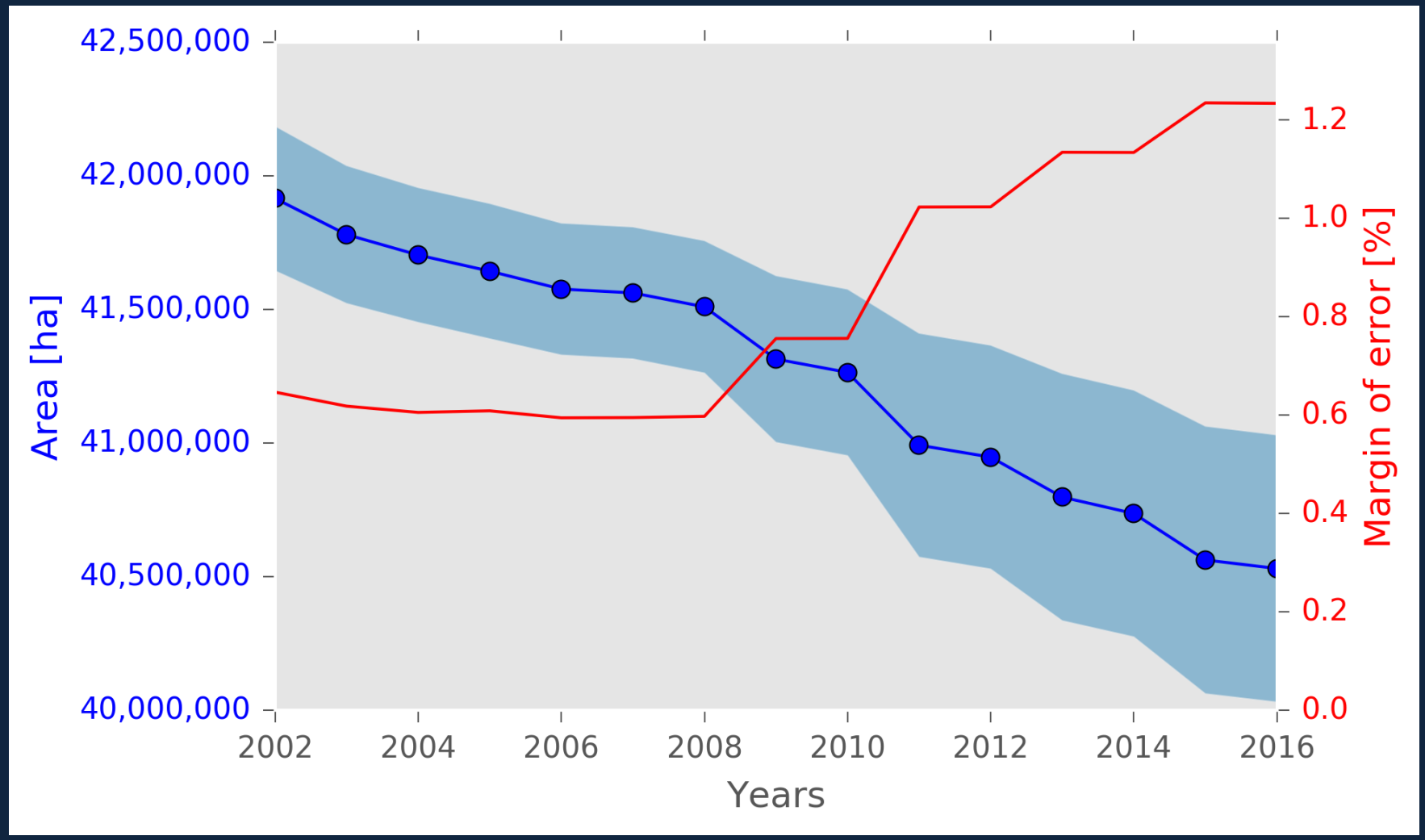
Stratification, 2000-2016



Zoom in to deforestation hotspot.

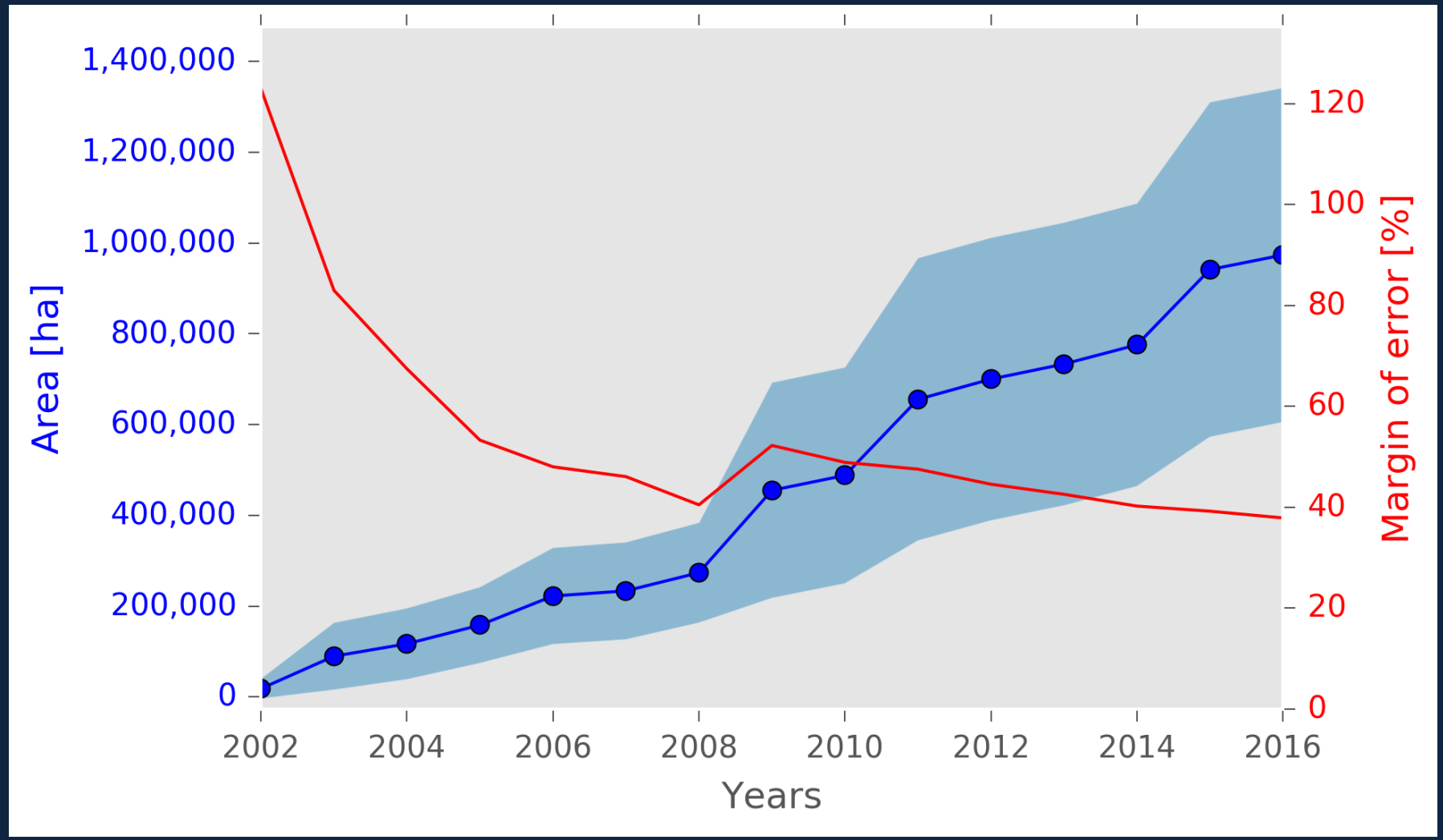
Multiple areas of sustained regrowth



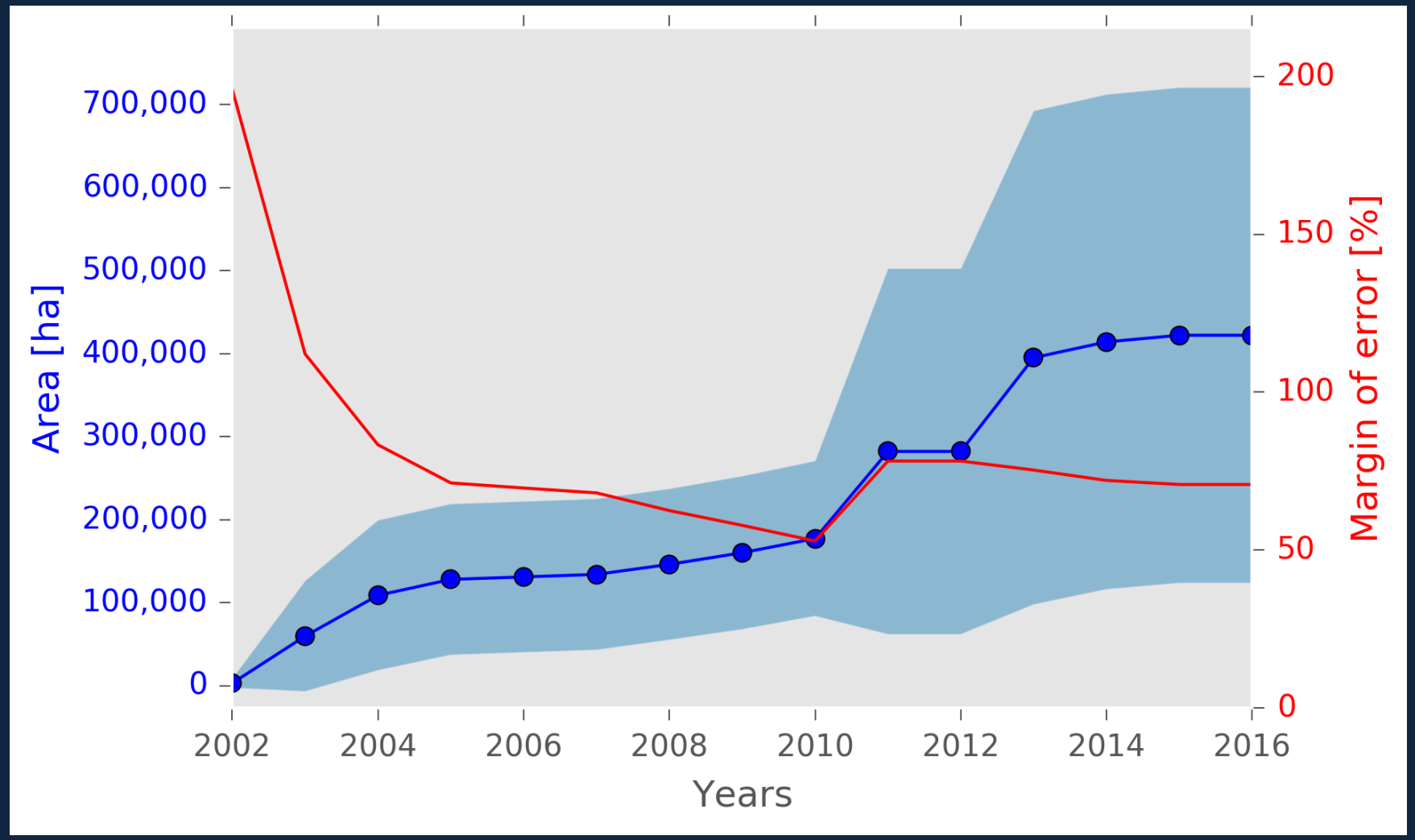


Estimated stable forest

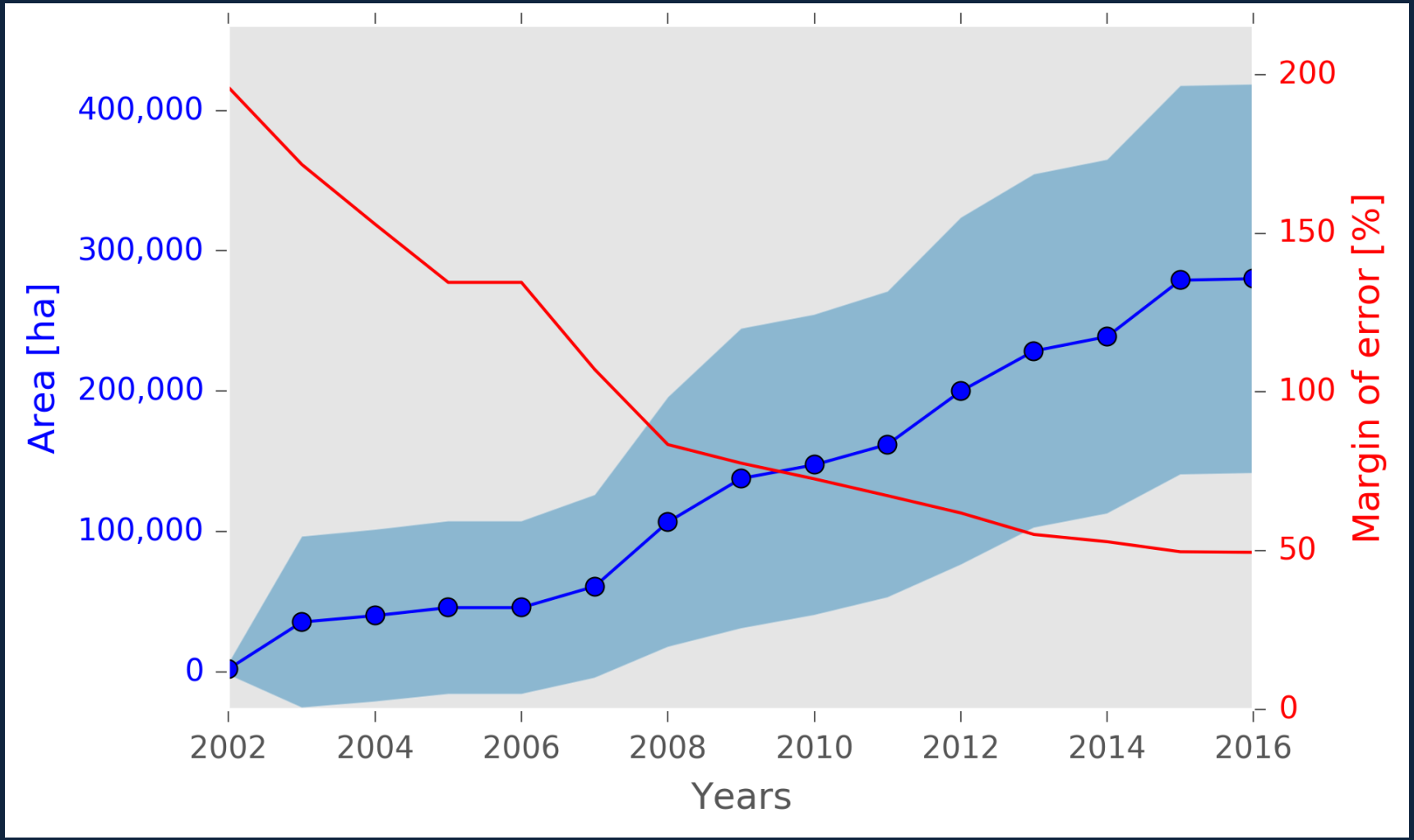
Margin of error = confidence interval / area estimate



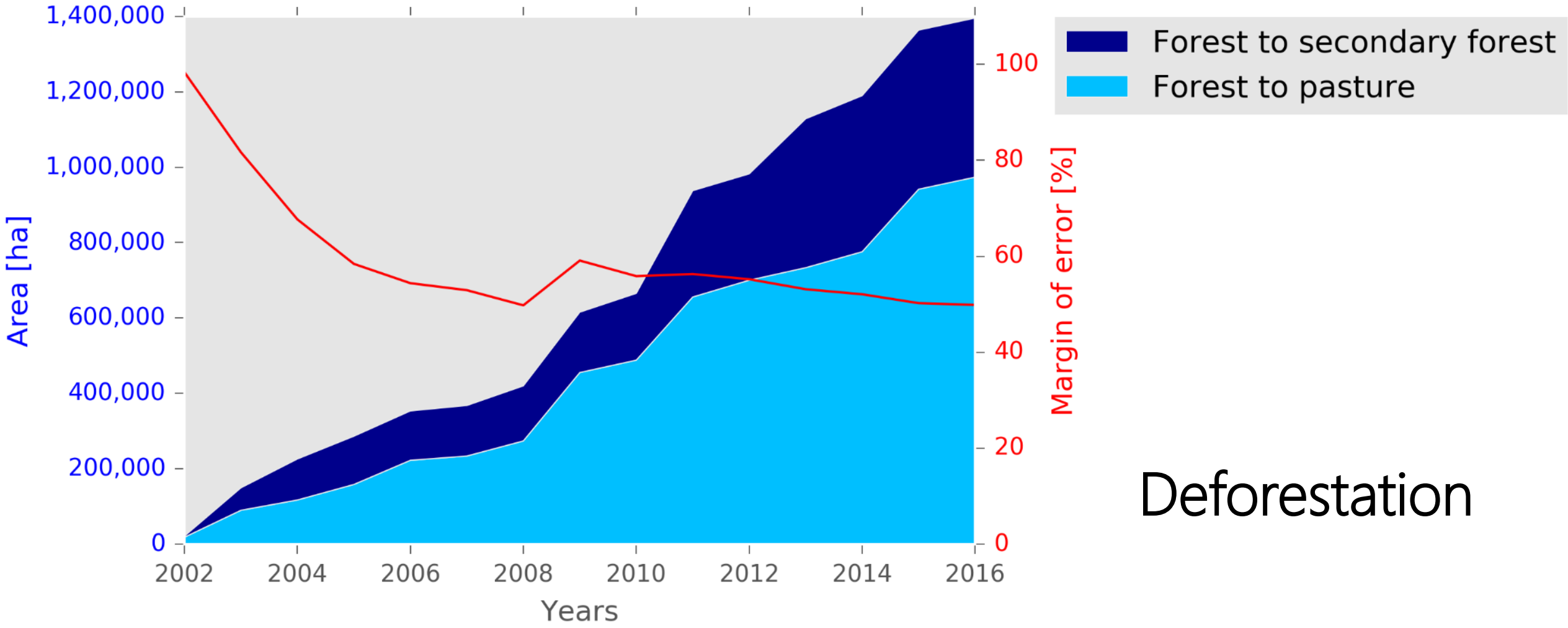
Estimated forest to pasture



Conversion of primary forest to secondary forest

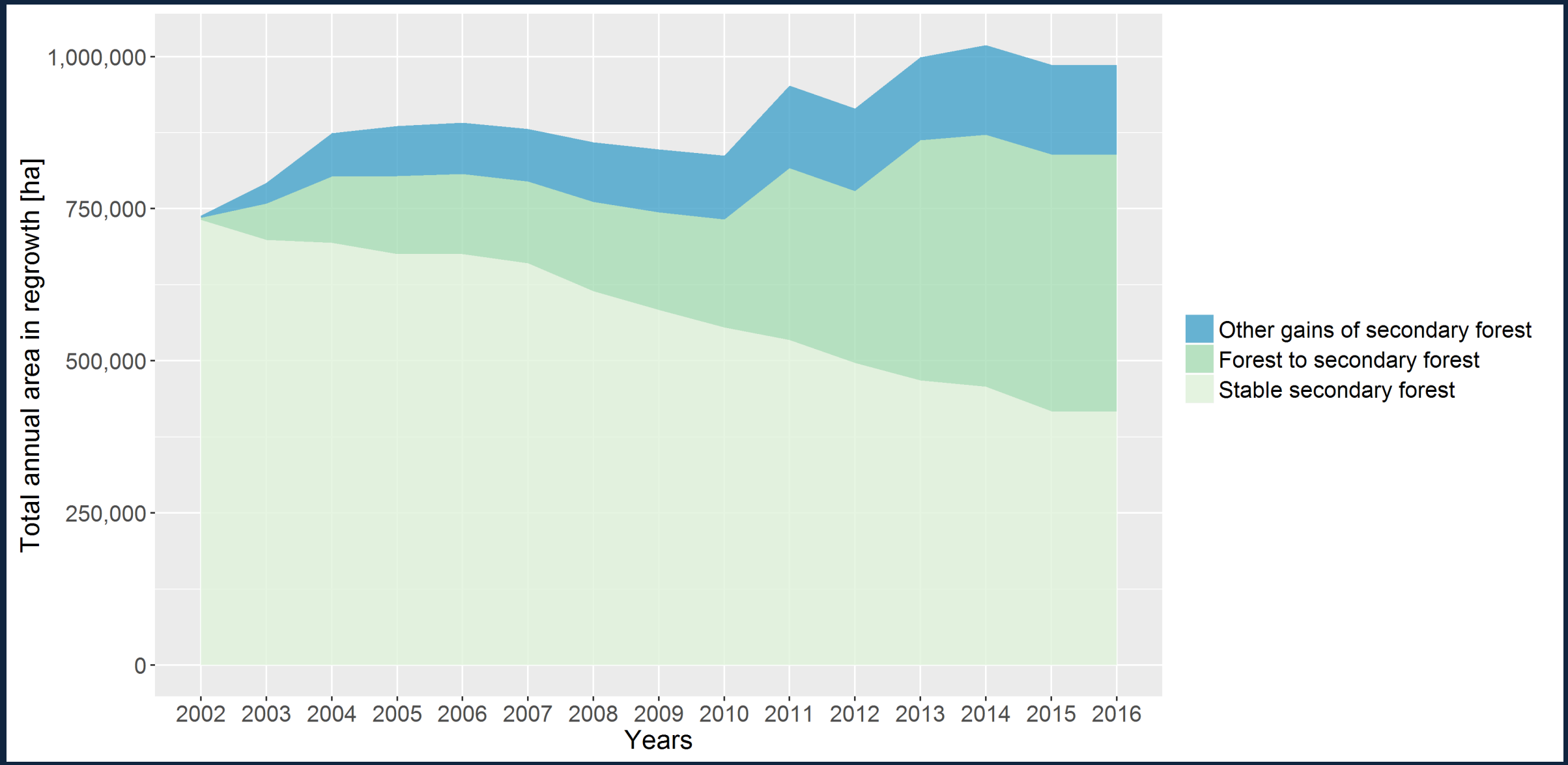


Loss of secondary forest



Deforestation

Estimated area of secondary forest



Conclusions and future directions

- Currently working with IDEAM for implementation (testing – not operational)
- Papers in preparation (one on method and one on results)
- Constructing annual estimators using single sample time-saving but imprecise – other approaches preferred? – more research needed
- CCDC/YATSM is currently being refined; accuracy and precision will be higher if more time spent on training data and reference sample
- Carbon bookkeeping model on top for Tier 3 compliant estimation of carbon emissions and removals (funding from NASA CMS 2016)

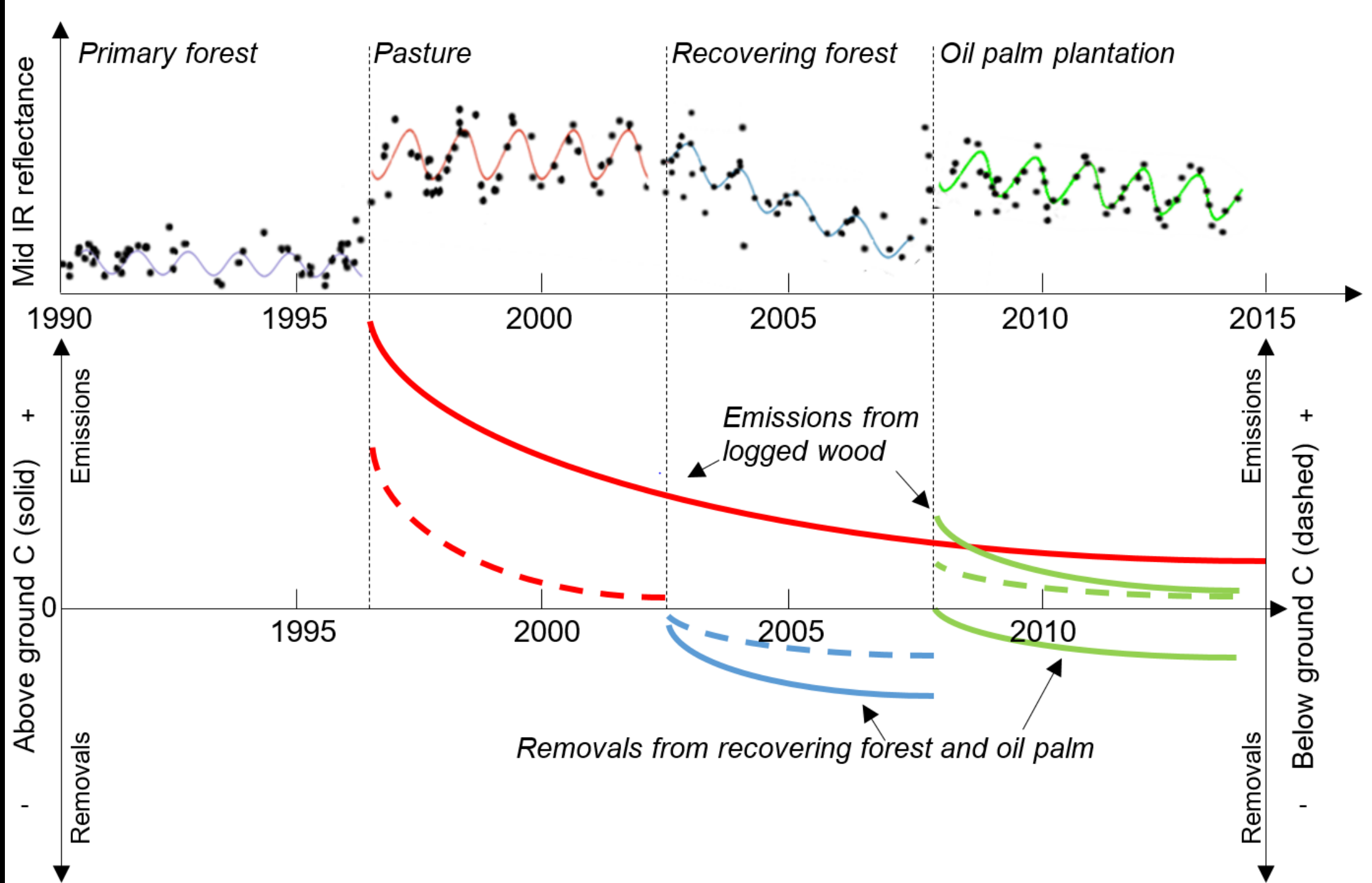


Figure from 2016 NASA CMS proposal (funded). Hypothetical illustration of pixel level carbon modeling framework. Upper plot shows the analysis by the presented prototype: land conversions triggers a carbon response that is modeled by book-keeping approach (lower plot).

Information and repositories

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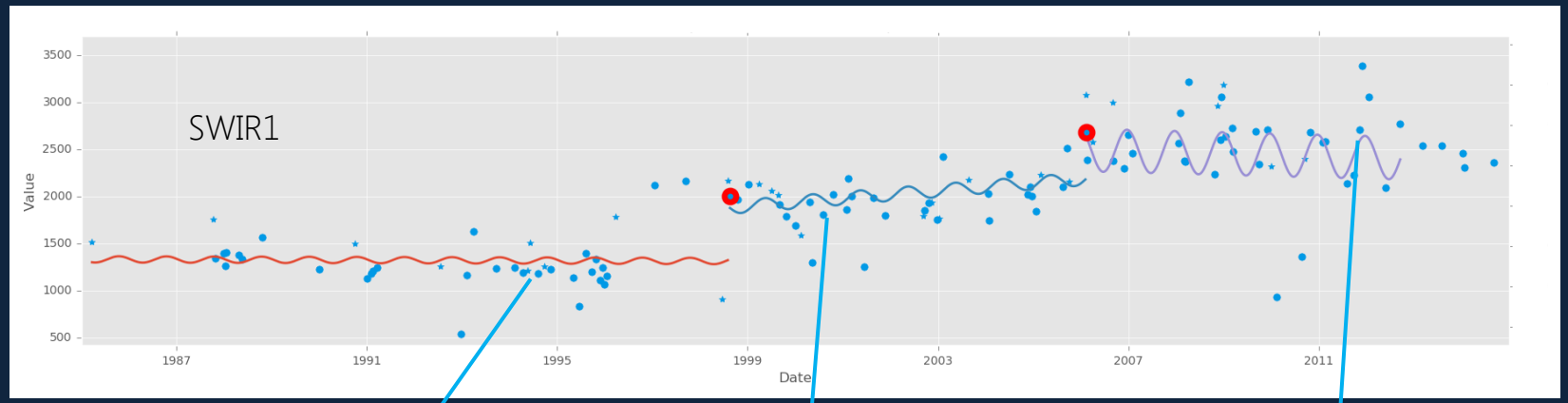
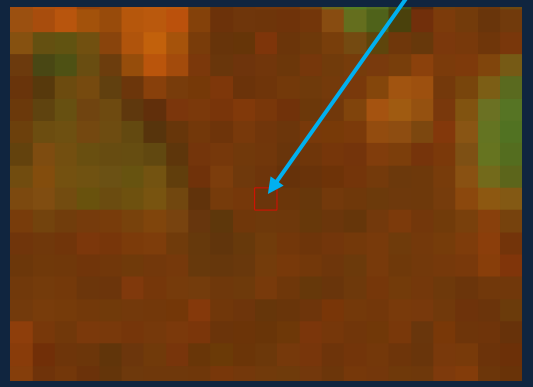
https://github.com/beeoda

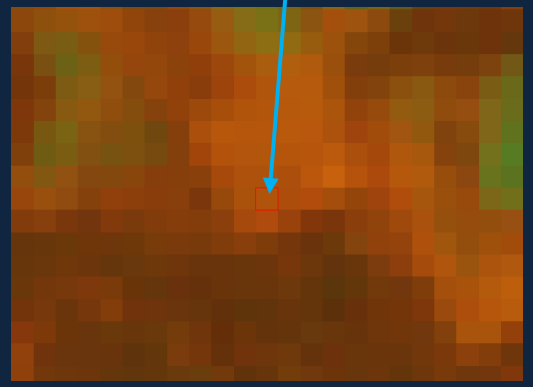
https://github.com/parevalo

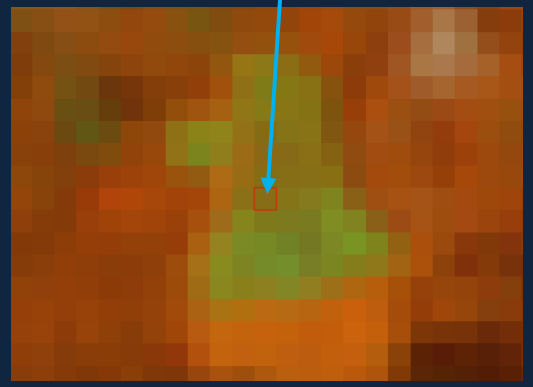
https://github.com/ceholden

Backup slides







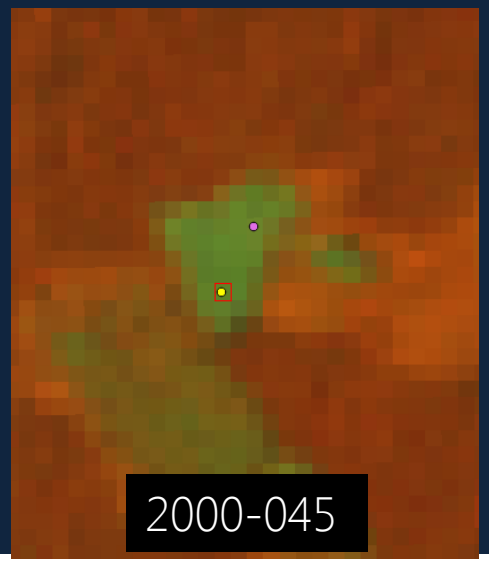


Forest

Regrowth

Pastures


1997-260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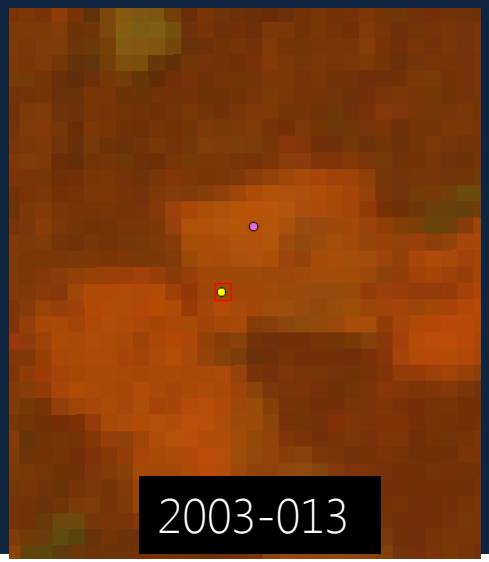
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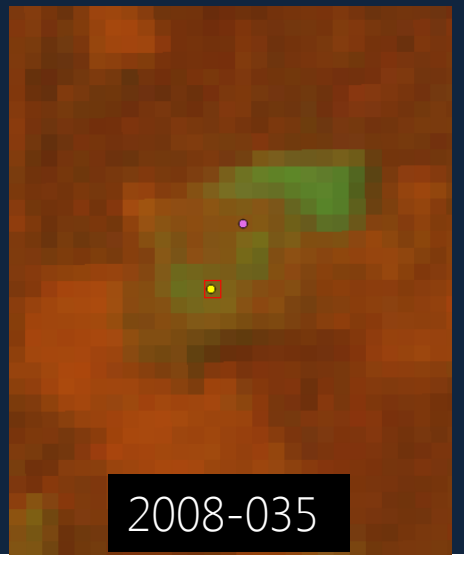
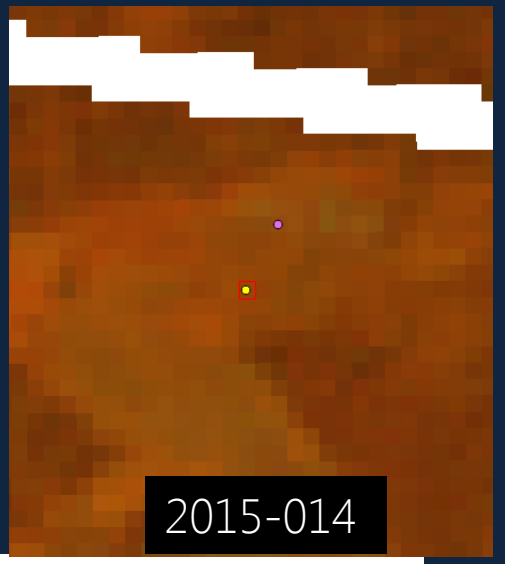
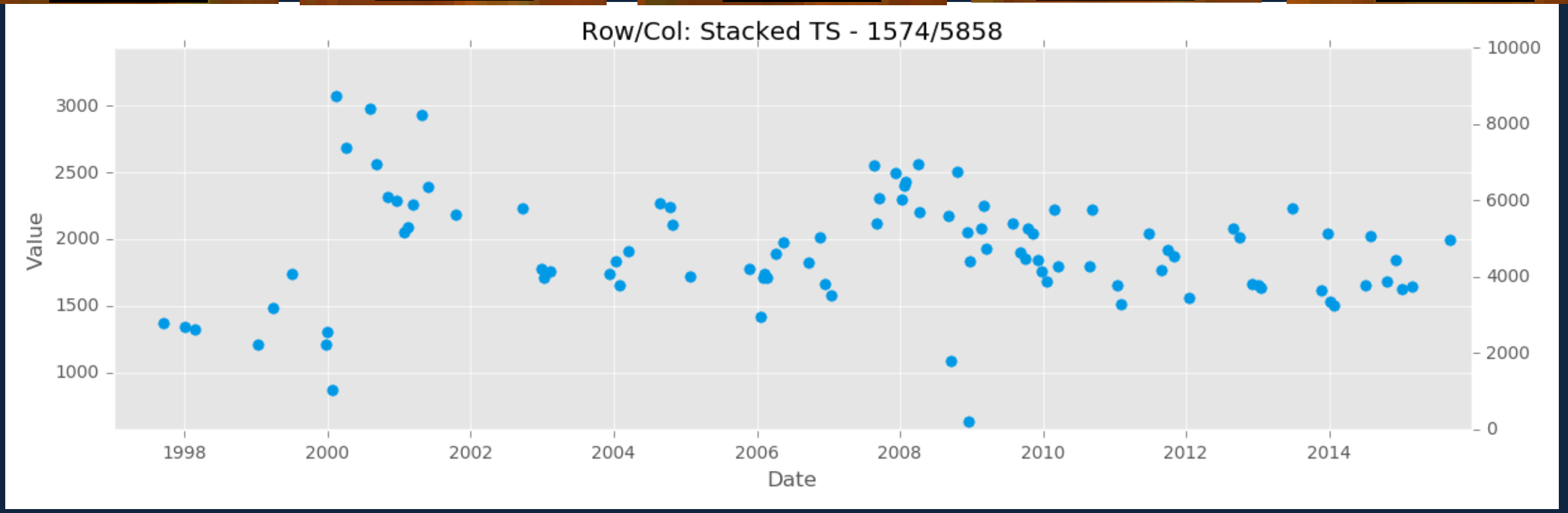

2008-035


2015-014


Row/Col: Stacked TS - 1574/5858
Value
Date
3000
2500
2000
1500
1000
10000
8000
6000
4000
2000
0
1998
2000
2002
2004
2006
2008
2010
2012
2014

Estimator of unbiased area proportion for each class:

$$\hat{\bar{Y}} = \sum_{h=1}^{H} N_h^* \bar{y}_h / N$$

From Stehman (2014)

Estimator of unbiased variance of $\hat{\bar{Y}}$:

$$\hat{V}(\hat{\bar{Y}}) = (1/N^2) \sum_{h=1}^{H} N_h^{*2} (1 - n_h^*/N_h^*) s_{yh}^2 / n_h^*$$

where the sample variance of the y_u values from stratum h is:

$$s_{yh}^2 = \sum^{u \in h} (y_u - \bar{y}_h)^2 / (n_h^* - 1)$$

and:

$$y_u = \begin{cases} 1 & \text{if pixel } u \text{ is reference class } k \\ 0 & \text{if pixel } u \text{ is not reference class } k \end{cases}$$

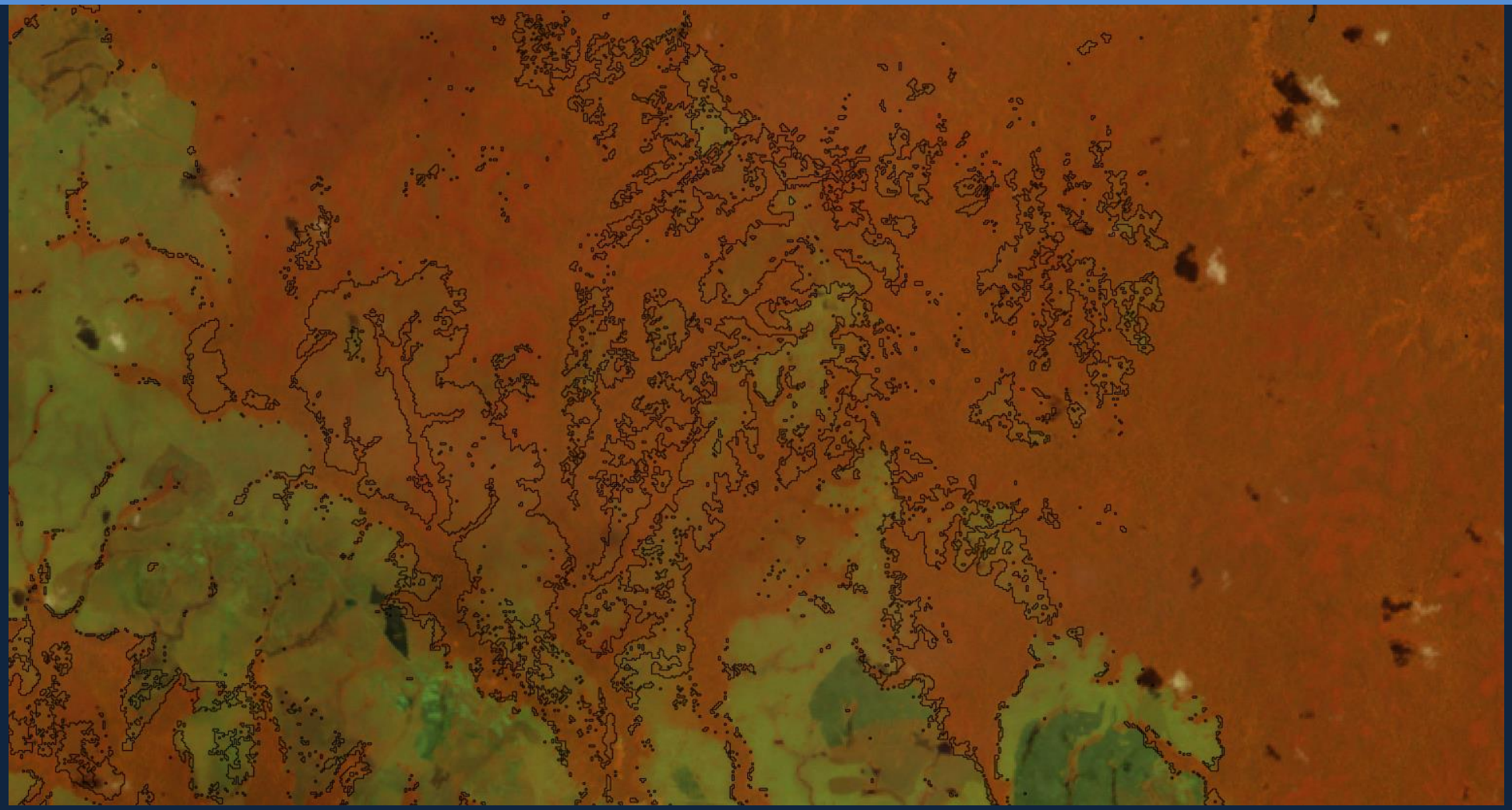
$\bar{y}_h$ is the sample mean of the y_u values in stratum h

H is the number of strata

N_h is the stratum size and N is the total size

n_h^* is the sample allocation to each stratum

Other approaches



Attempt to map other land cover types