A Pantropical Analysis of "Bright Spots" In Exceptional Restoration and Avoided Carbon Loss Outcomes

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WHRC

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Objective

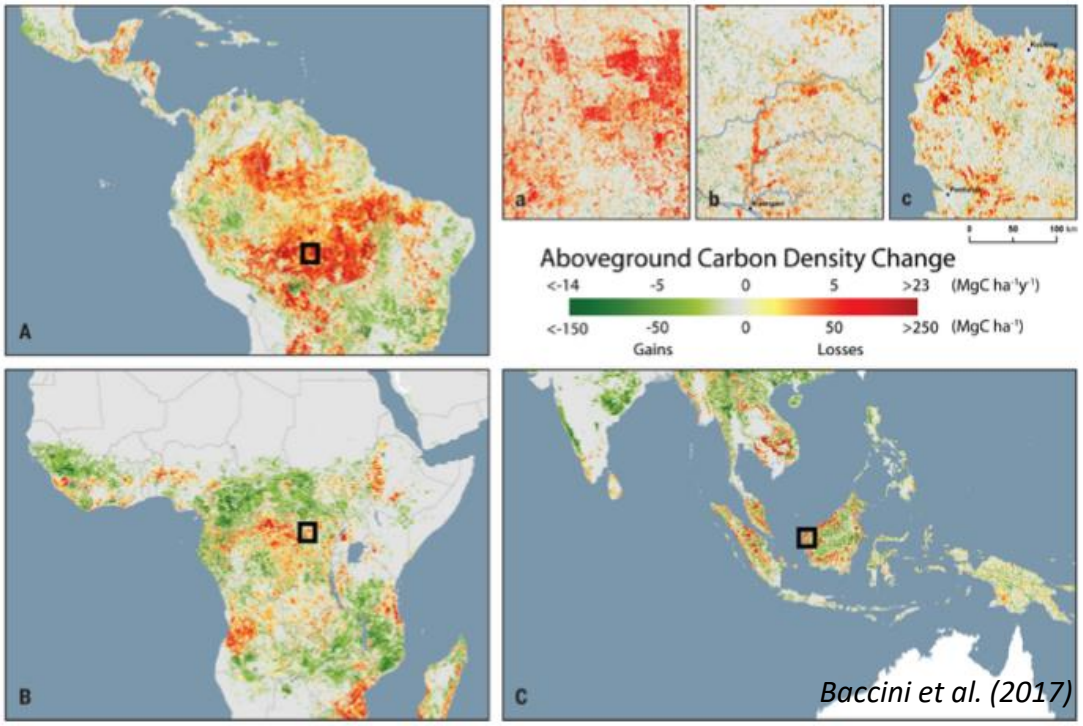
Identify exceptional restoration and/or avoided loss (i.e., positive carbon) outcomes, or

bright spots.

The ultimate goal of this analysis is to bring attention to these land climate success stories, not only so that they can be appropriately recognized, but also – and more importantly – so that their underlying drivers can be identified and understood and, to the extent possible, these results can be emulated in other jurisdictions and associated management contexts.

Biomass Change Data

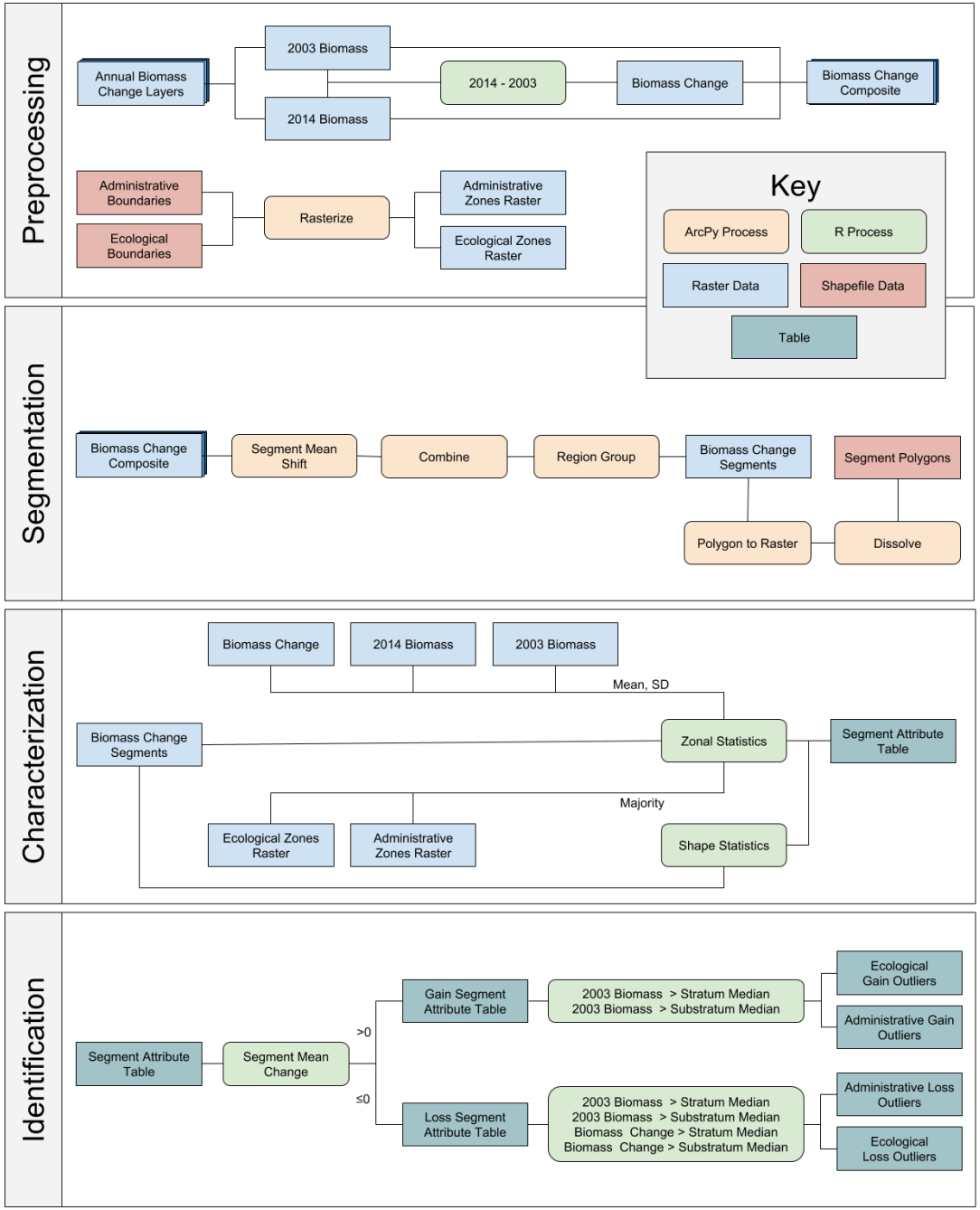
- Baccini et al. (2017)
- Aboveground Biomass Density Model
- MODIS, LIDAR, *in situ*
- Annual, 2003-2014
- ~500 m spatial resolution

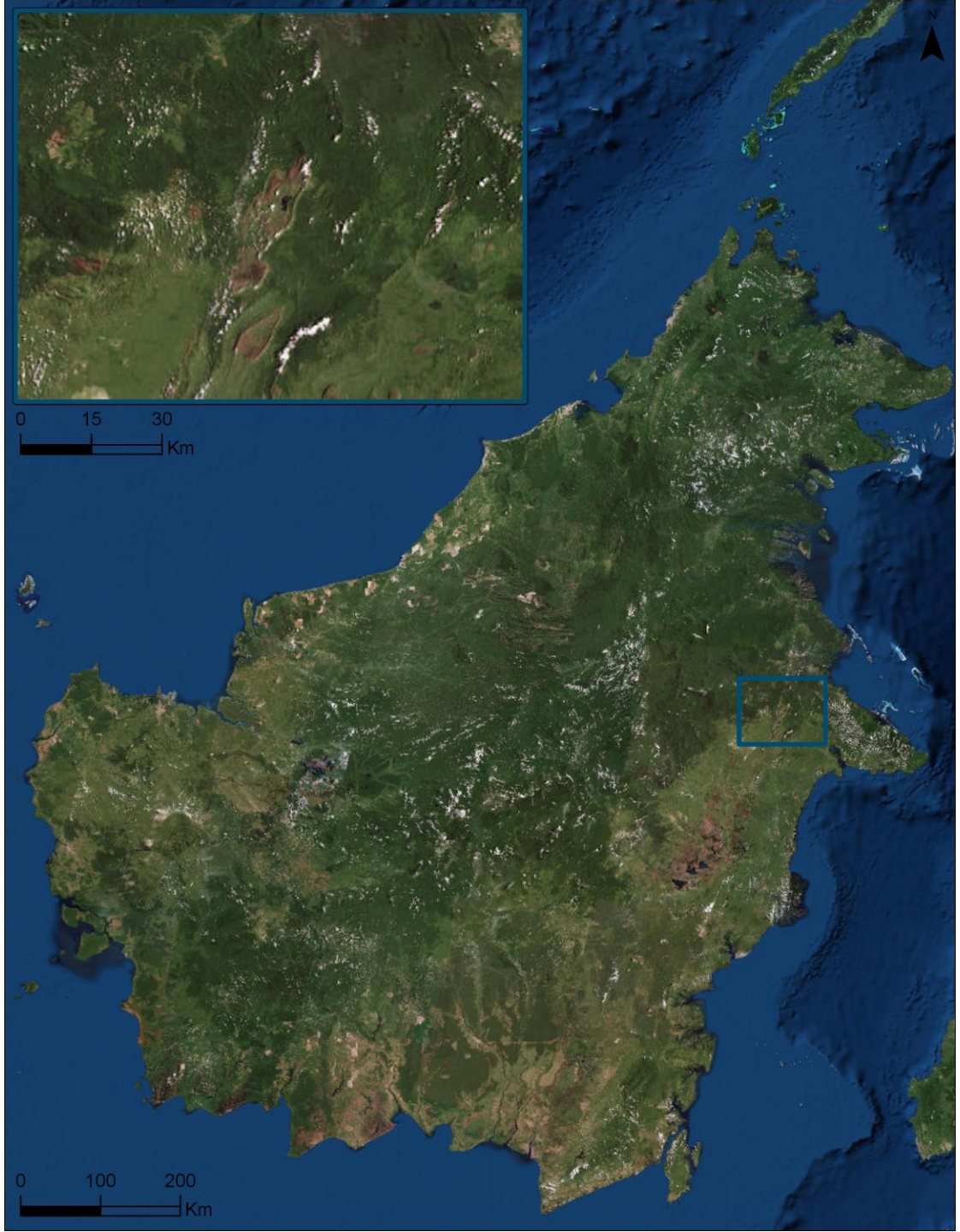


Methods

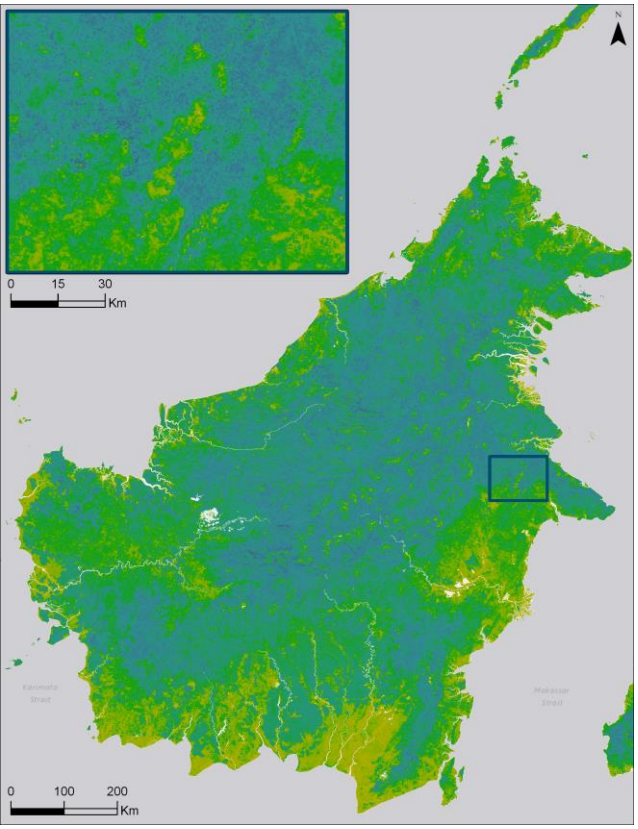
1. *Preprocessing* of the biomass change data set.
2. *Segmentation* of the data into regions with similar biomass density and change characteristics.
3. *Characterization* of segments in terms of biophysical and political attributes.
4. *Identification* of a population of positive outliers for more in-depth study.
5. *Attribution* undertaken for a subset of positive outliers or “bright spots.”

Processing Flow

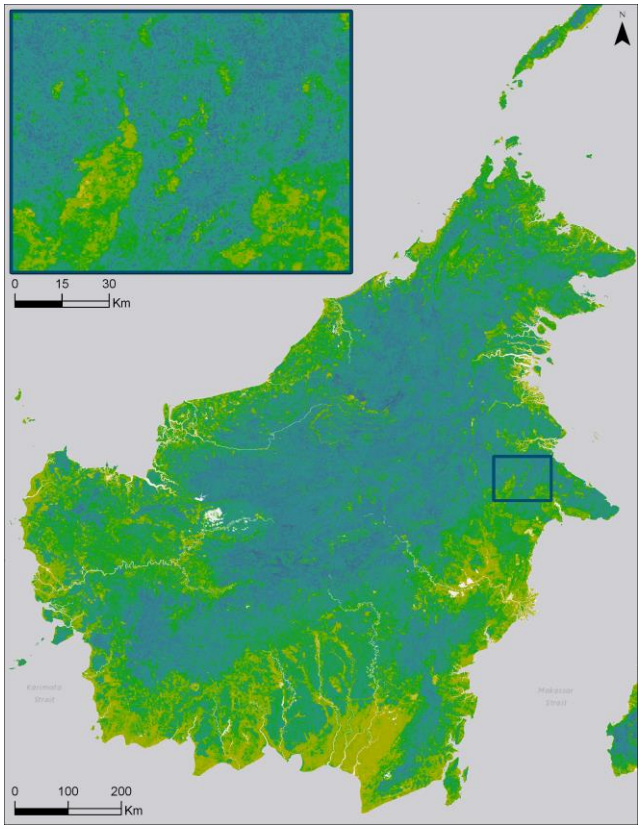



N
0 15 30
Km
0 100 200
Km

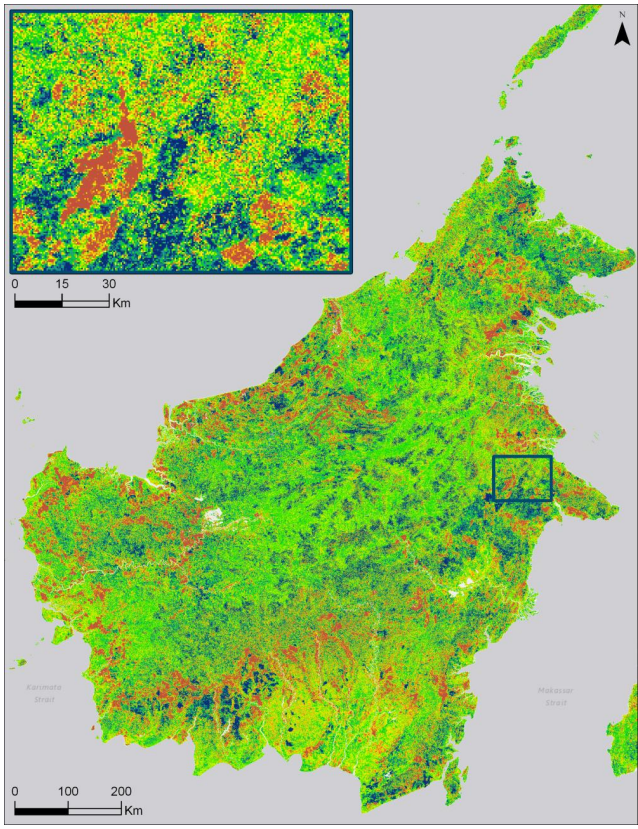
Biomass Density 2003



Biomass Density 2014

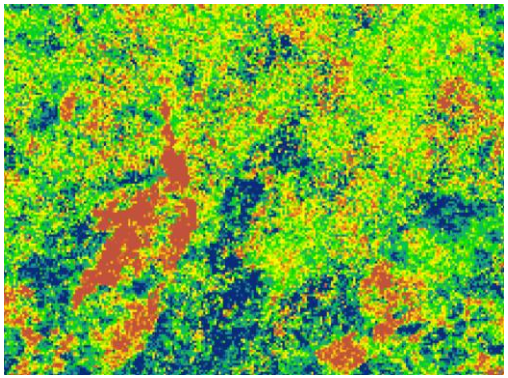


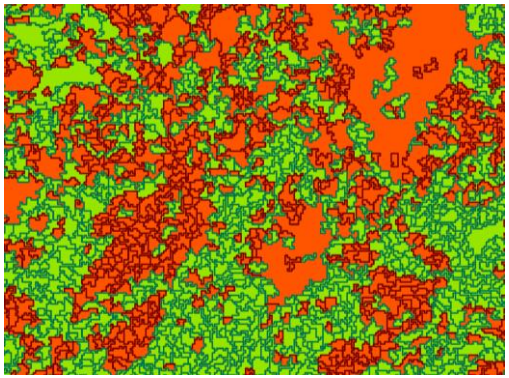
Biomass Density Change 2003-2014



Segmentation

- Segment Mean Shift
  - Identify segments or features by grouping adjacent pixels with similar spectral characteristics
  - Parameters to control degree of spatial and spectral smoothing
  - Implemented in ArcGIS Pro

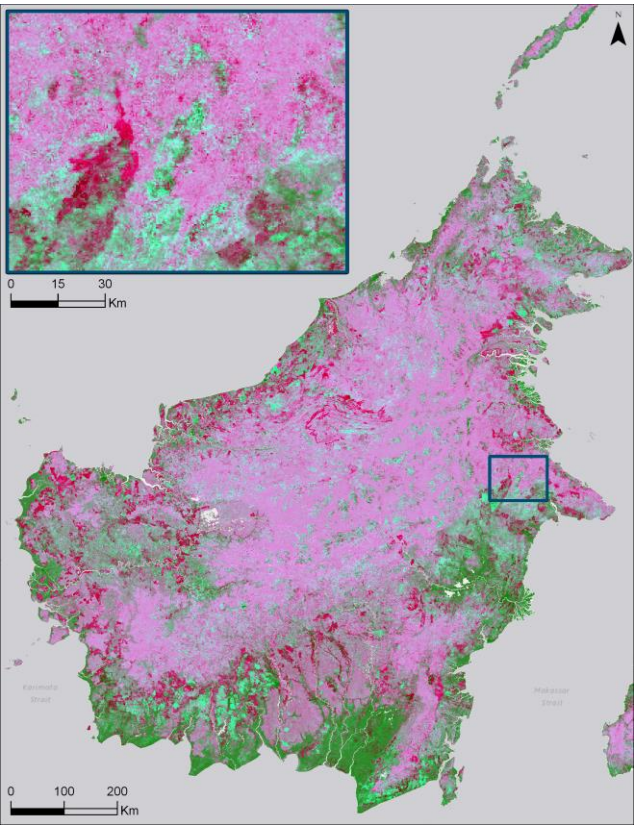


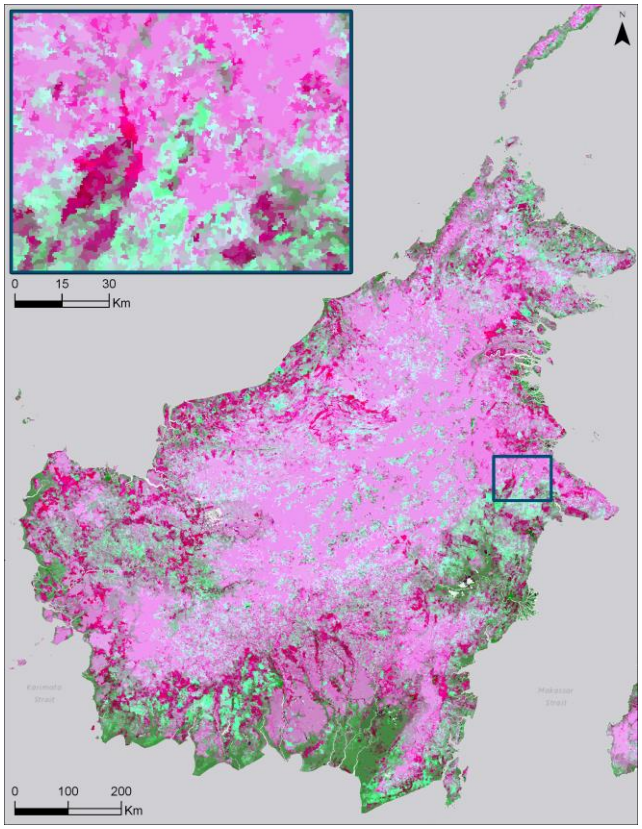


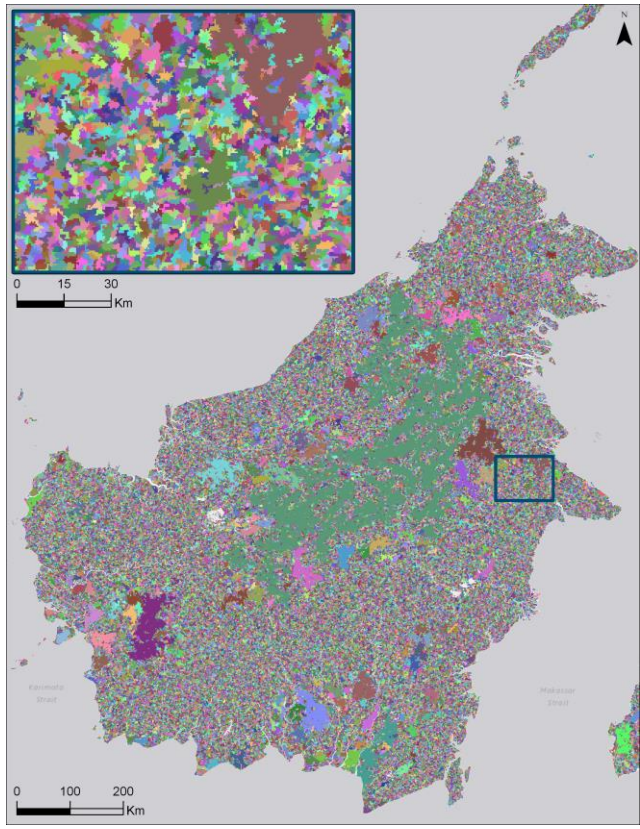
3-Band Biomass Composite
(RGB = 2003, Change, 2014)

Mean Shift Segmentation

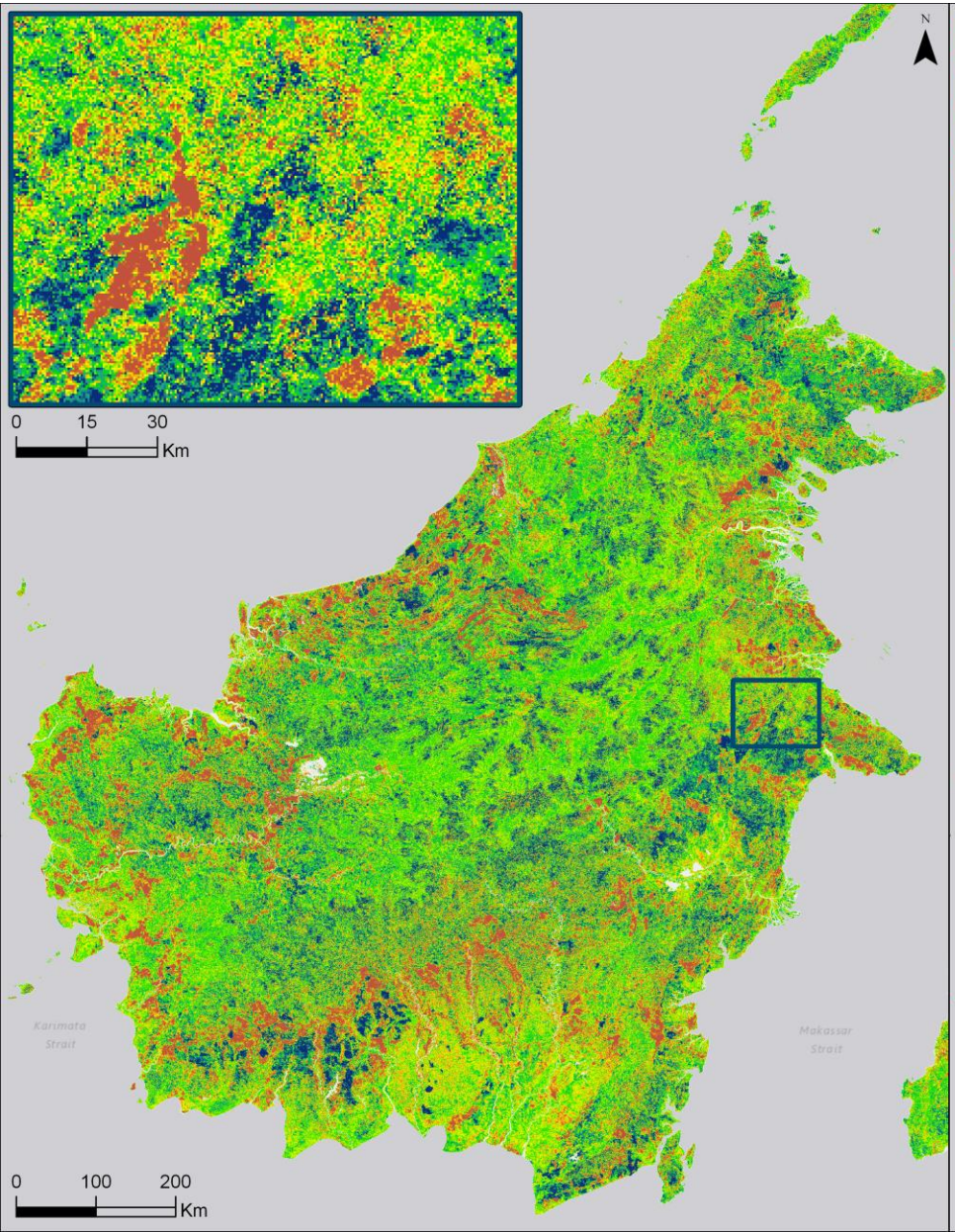
Discrete Segments



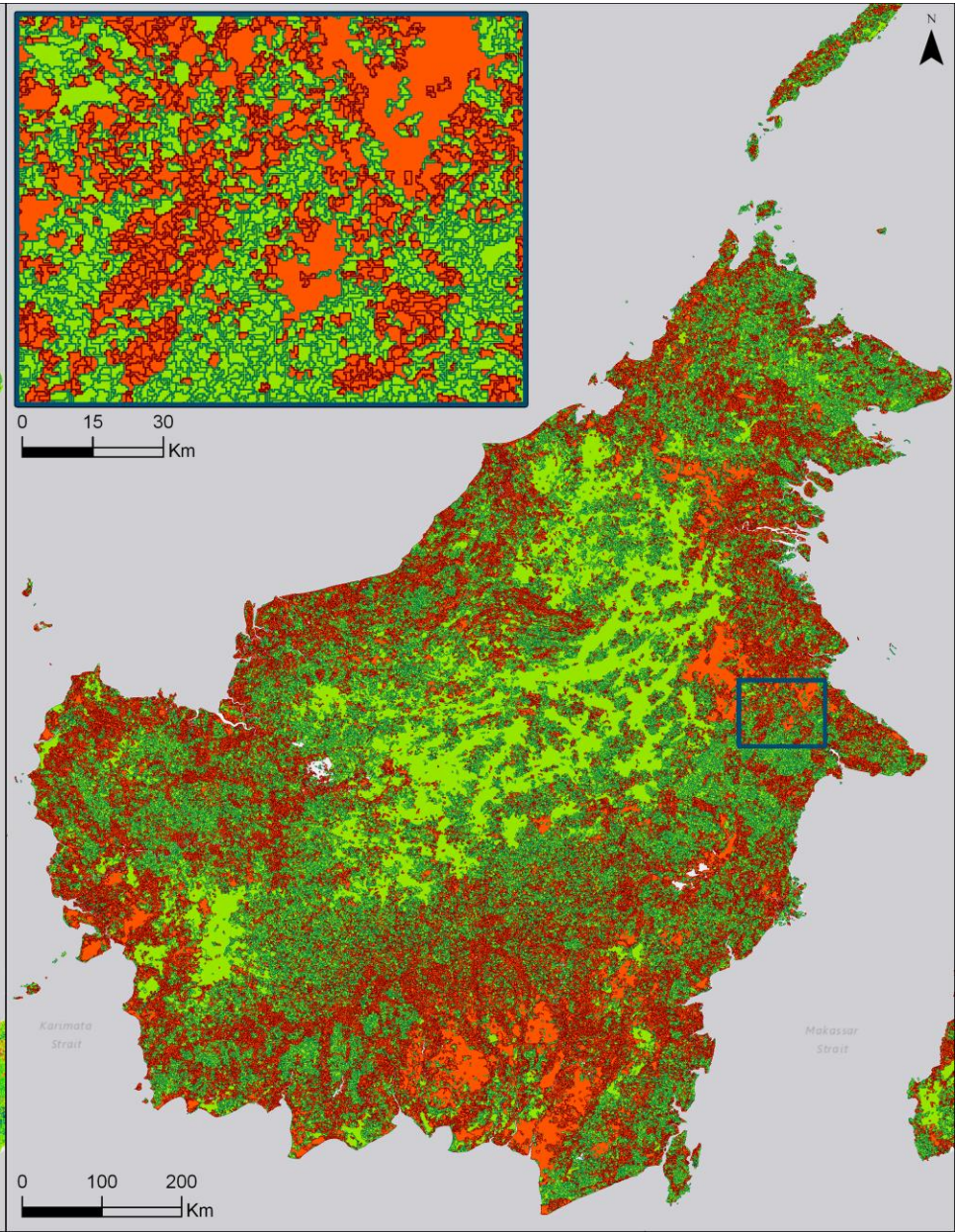




Biomass Density Change 2003-2014



Segments by Mean Change



Positive outlier:

Segment in the landscape where either the gain in carbon density was higher than expected or the loss in carbon density was lower than expected relative to a background reference – ecoregional or political – stratum, with these two broad categories corresponding to either exceptional restoration or avoided loss outcomes, respectively.

Outlier Identification

- Strata
  - Continental
  - Ecological
    - Biome
    - Ecoregion
  - Political
    - Country
    - State/Province
- Segment percentiles calculated within each stratum
- Segments ranked by maximum across strata
  - Gain: 2003 biomass density
  - Loss: 2003-2014 biomass change
- Top 5% of segments by area identified as outliers

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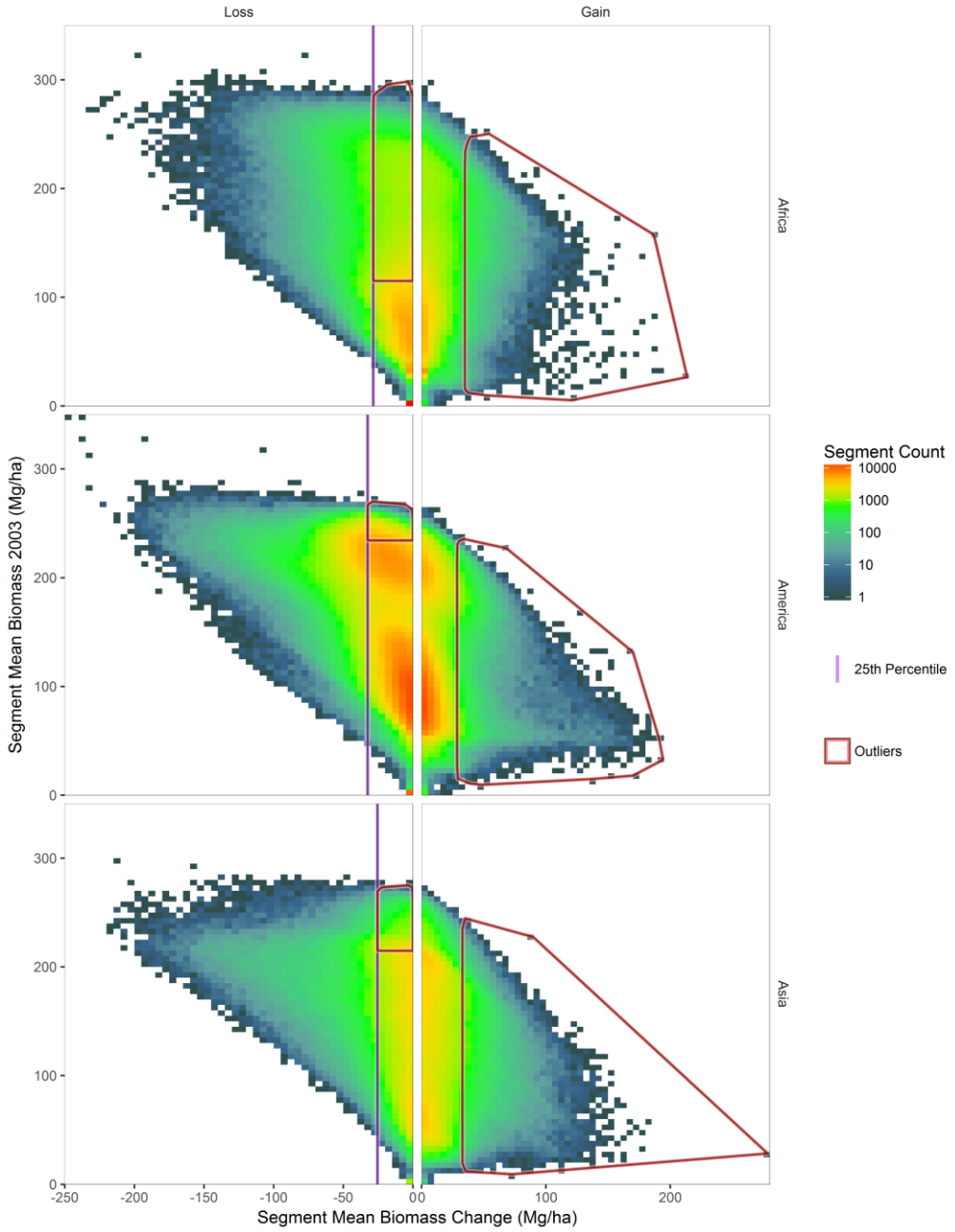

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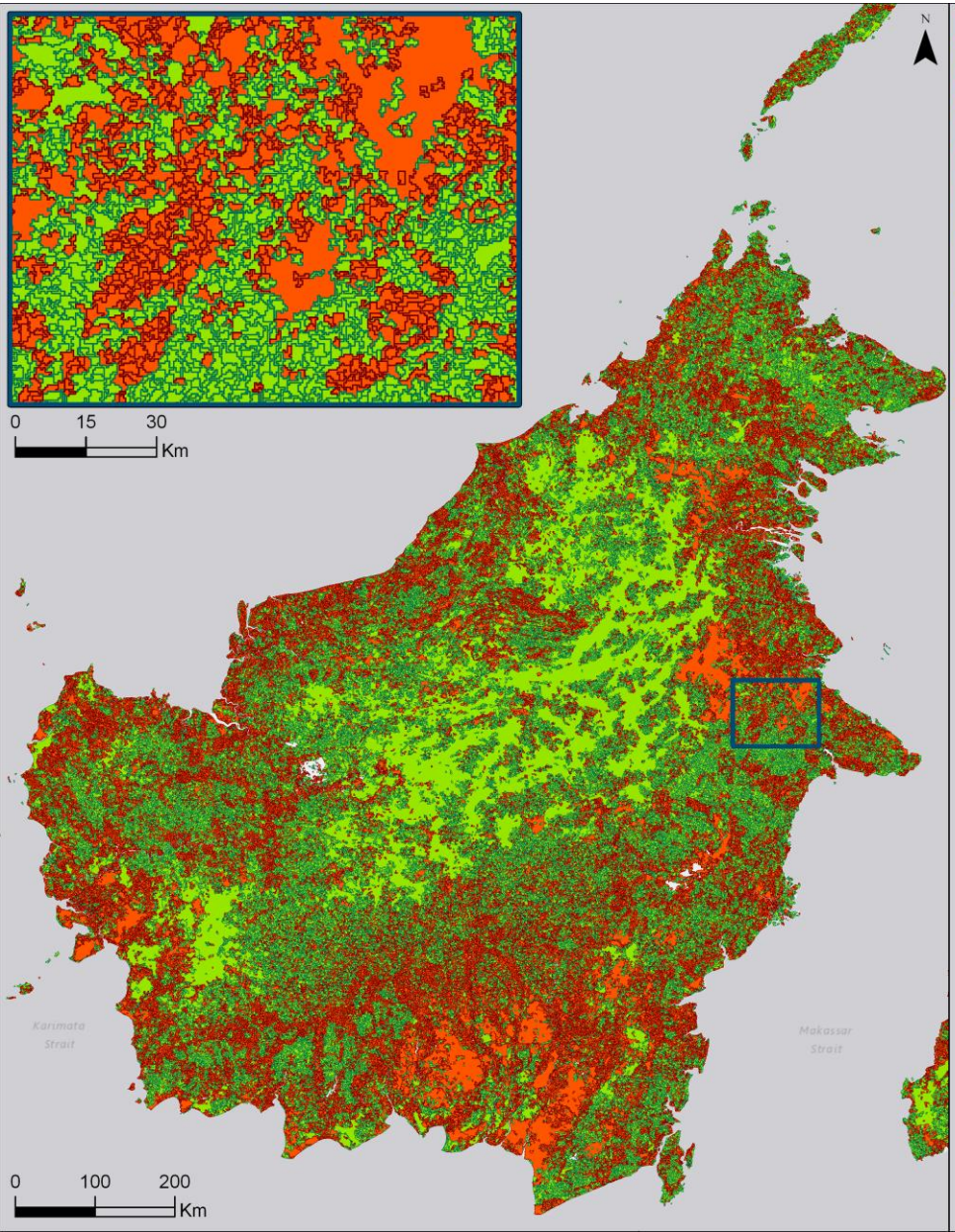
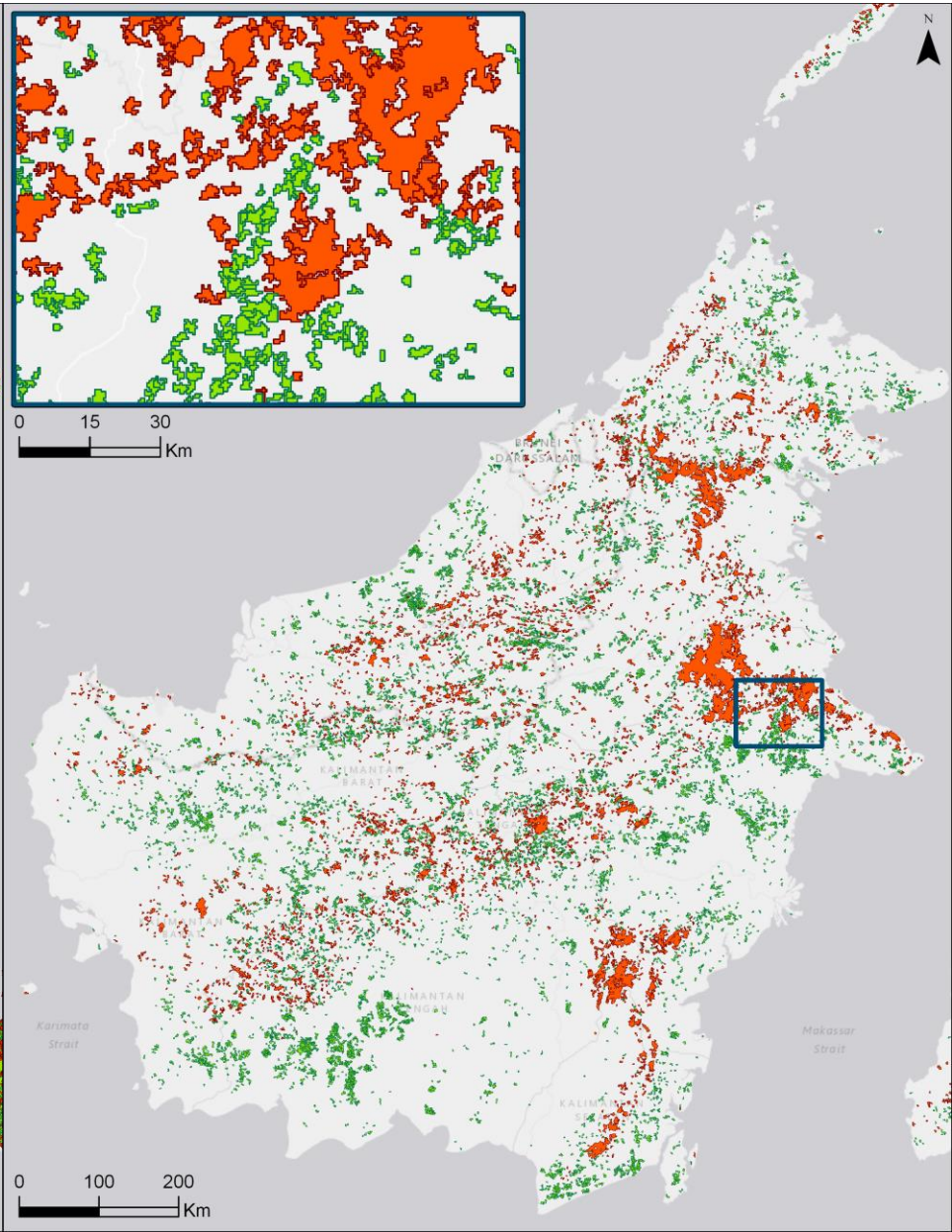
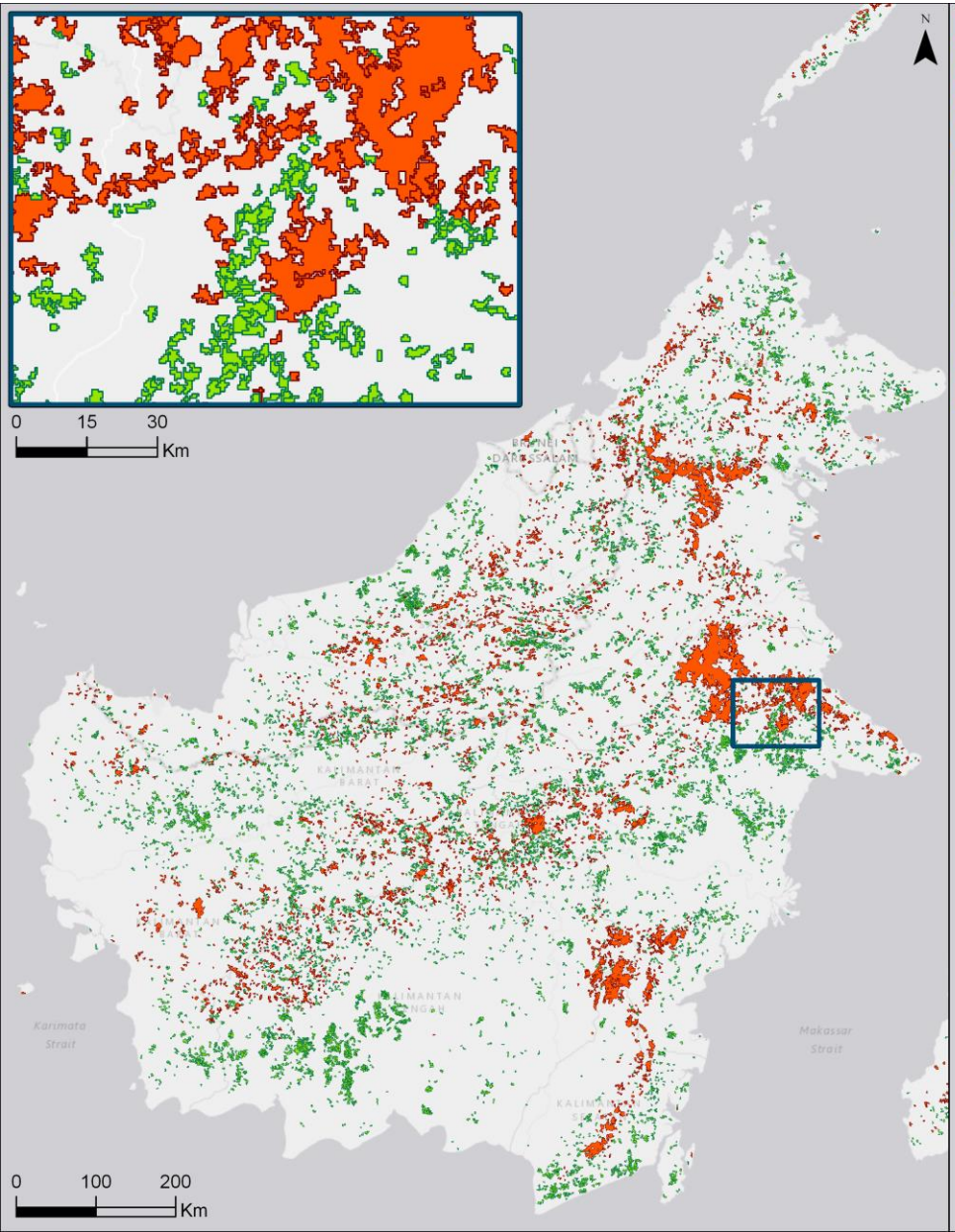


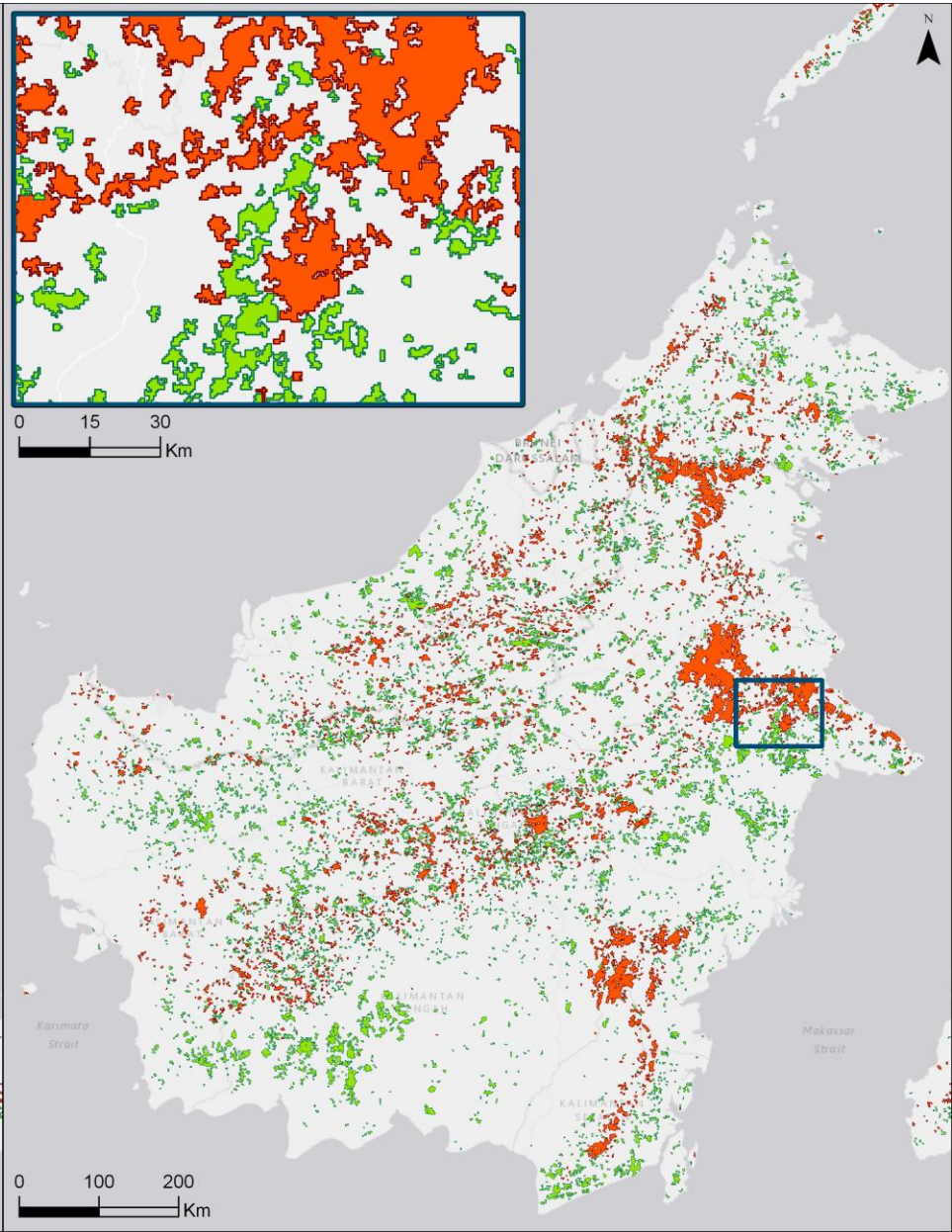
Identified Outlier Segments



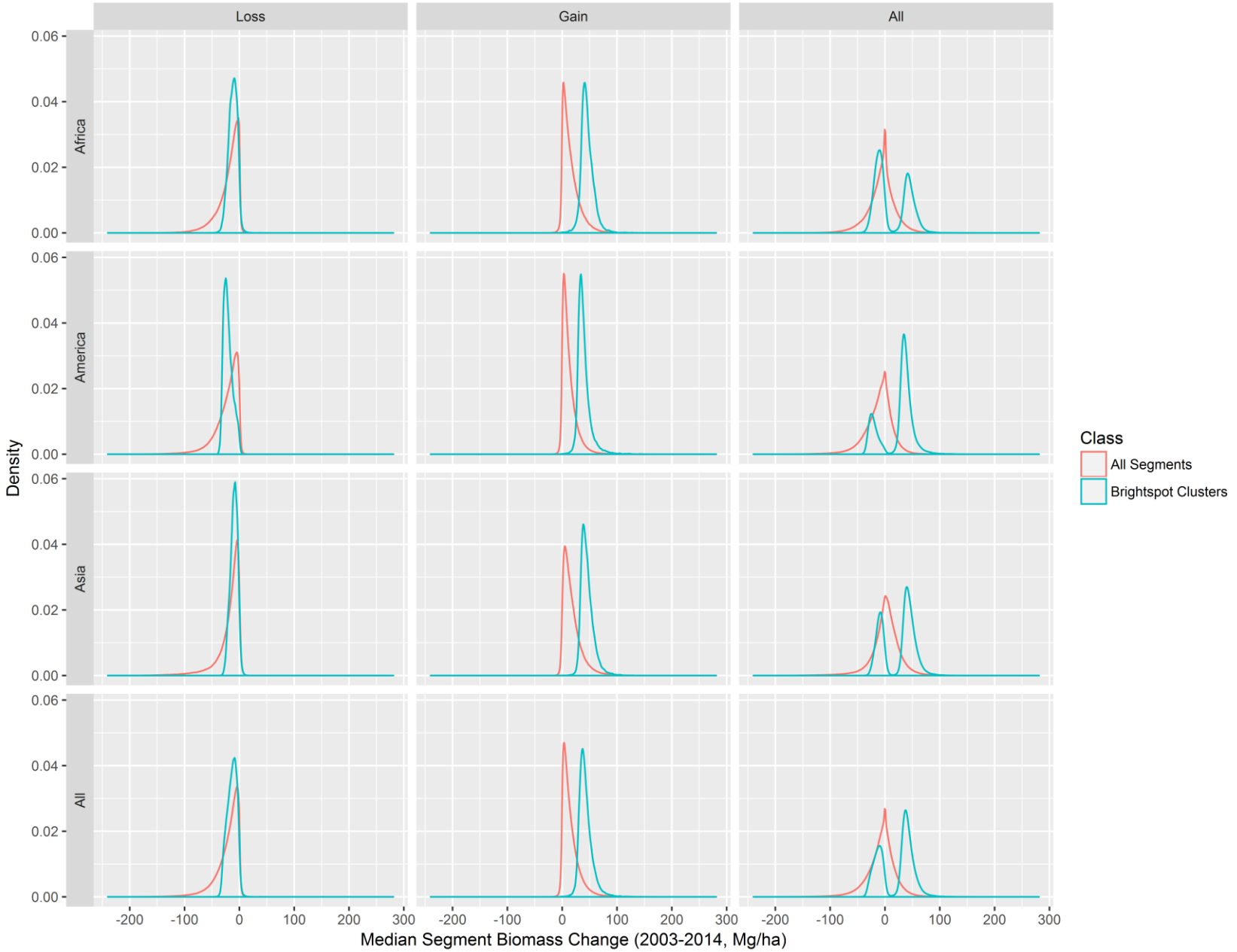
Identified Outlier Segments

Segments Aggregated to Clusters

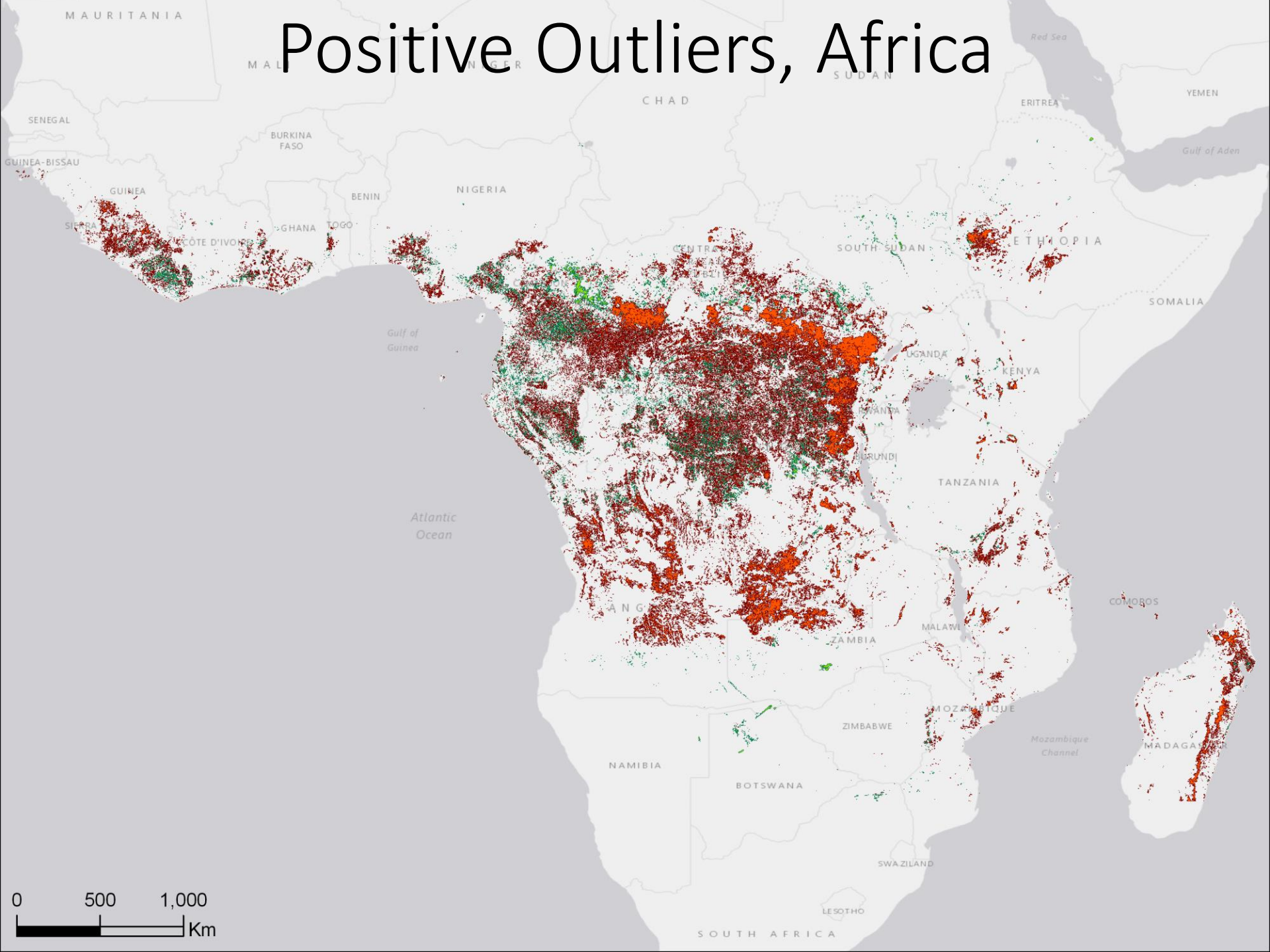




Median Biomass Change 2003-2014 (Mg/ha) Segment and Bright Spot Distributions

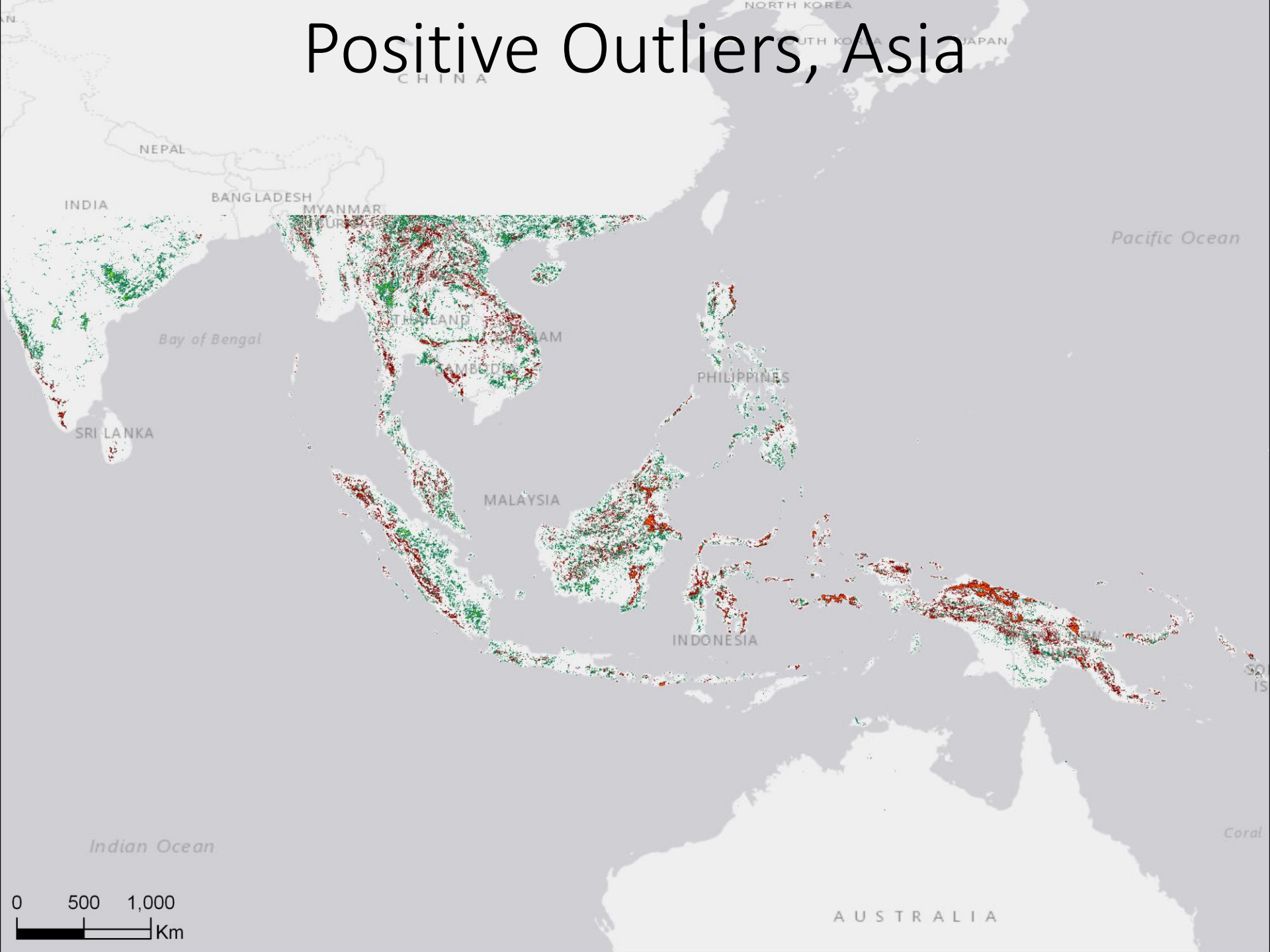


Positive Outliers, Africa



Positive Outliers, America

Positive Outliers, Asia



Segmentation, Identification, and Aggregation Results

Region	Change	Segment Count	Area (ha)	Outlier Count	Outlier Area (ha)	Outlier %	Outlier Area %	Cluster Count	Segment Aggregation
Africa	Loss	637,619	1,852,375,626	138,306	92,618,739	21.7%	5.0%	16,953	-87.7%
	Gain	406,324	284,938,672	34,547	14,246,634	8.5%	5.0%	12,908	-62.6%
	All	1,043,943	2,137,314,298	172,853	106,865,373	16.6%	5.0%	29,861	-82.7%
America	Loss	1,488,130	951,215,714	33,578	47,553,573	2.3%	5.0%	9,395	-72.0%
	Gain	732,320	528,350,540	66,182	26,417,275	9.0%	5.0%	28,155	-57.5%
	All	2,220,450	1,479,566,254	99,760	73,970,848	4.5%	5.0%	37,550	-62.4%
Asia	Loss	452,375	463,739,663	33,302	23,186,734	7.4%	5.0%	10,552	-68.3%
	Gain	558,235	520,207,843	64,825	26,010,304	11.6%	5.0%	18,650	-71.2%
	All	1,010,610	983,947,506	98,127	49,197,038	9.7%	5.0%	29,202	-70.2%
All	**Loss**	**2,578,124**	**3,267,331,003**	**205,186**	**163,359,046**	**8.0%**	**5.0%**	**36,900**	**-82.0%**
	Gain	**1,696,879**	**1,333,497,055**	**165,554**	**66,674,213**	**9.8%**	**5.0%**	**59,713**	**-63.9%**
	All	**4,275,003**	**4,600,828,058**	**370,740**	**230,033,259**	**8.7%**	**5.0%**	**96,613**	**-73.9%**
Borneo	*Loss*	*61,482*	*31,608,251*	*4,055*	*3,423,591*	*6.6%*	*10.8%*	*1,808*	*-55.4%*
	Gain	*64,370*	*41,136,327*	*9,915*	*3,943,966*	*15.4%*	*9.6%*	*2,747*	*-72.3%*
	All	*125,852*	*72,744,578*	*13,970*	*7,367,557*	*11.1%*	*10.1%*	*4,555*	*-67.4%*

Anthropogenic	Developed	Low intensity
		High intensity
		Transportation
	Agriculture	Terrace
		Shifting
		Soy
		Mixed
	Plantation	Palm oil
		Eucalyptus
		Rubber
		Timber
		Mixed
	Logging	Selective
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	Mining	
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	Scrub	
	Rangeland	
	Wetland	
Mixed	Rural complex	
	Riparian buffer	
Other	Burn	
	Barren	
	Water	Open water
		Stream
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	Data issue	Cloud
		Mask-nodata
		Extreme values
		Other

← Land Use/Land Cover Classes

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Classification/Attribution Needs

- Visualize change over time
- Examine spatial (landscape) context
- Assimilate and synthesize diverse data sources
- Robust data entry interface

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- …Fast, Flexible, Fool Friendly


♫ SHINY ♫

- Challenge:
  - Querying, displaying, and manipulating geospatial data across global extents and scales
- Obstacle:
  - R loads all objects to memory
  - Stack overflow: priceless web resource, scourge of servers
- Solution:
  - PostGIS – Object-relational database. R/Shiny ingests only the desired subset of data requested by SQL query.
    - (Spatial) Indexing!
  - Geoserver – Serve and cache map tile services to dynamically visualize local raster and vector datasets

Activate Selection

Cluster UID

Country

Stop App + Close

status	uid	change	cell_count	b03_mea	b14_mea	bch_mea	b03_med	b14_med	bch_med	b03_min	b14_min	bch_min	b03_max	b14_max	bch_max	country

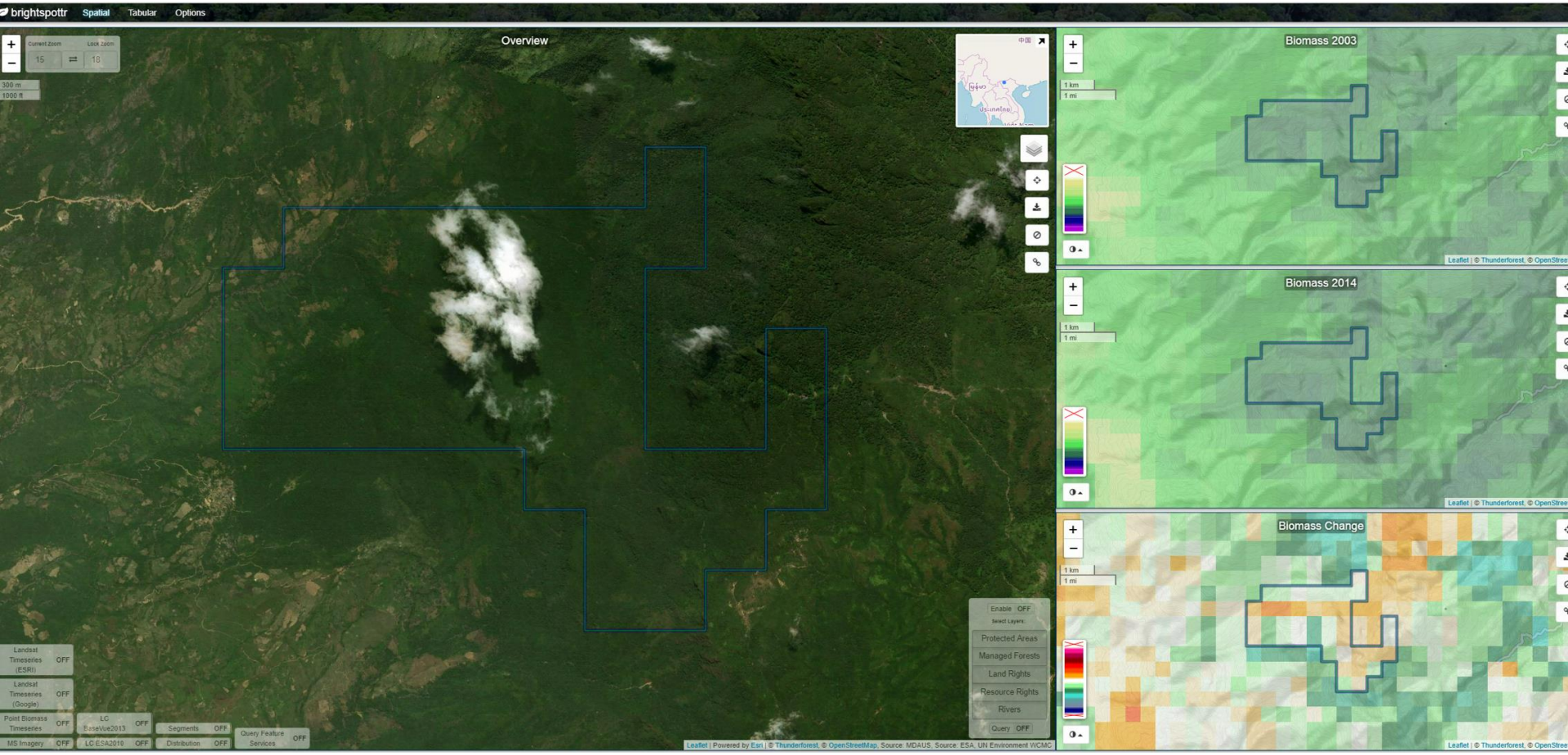
UID	Change	Driver ID	Location	Bearing	From	To	Transition	Matrix	Protected Area	Flags	Comments	Confidence	Status	
		a			LULC	LULC		If Relevant				0-10		Submit

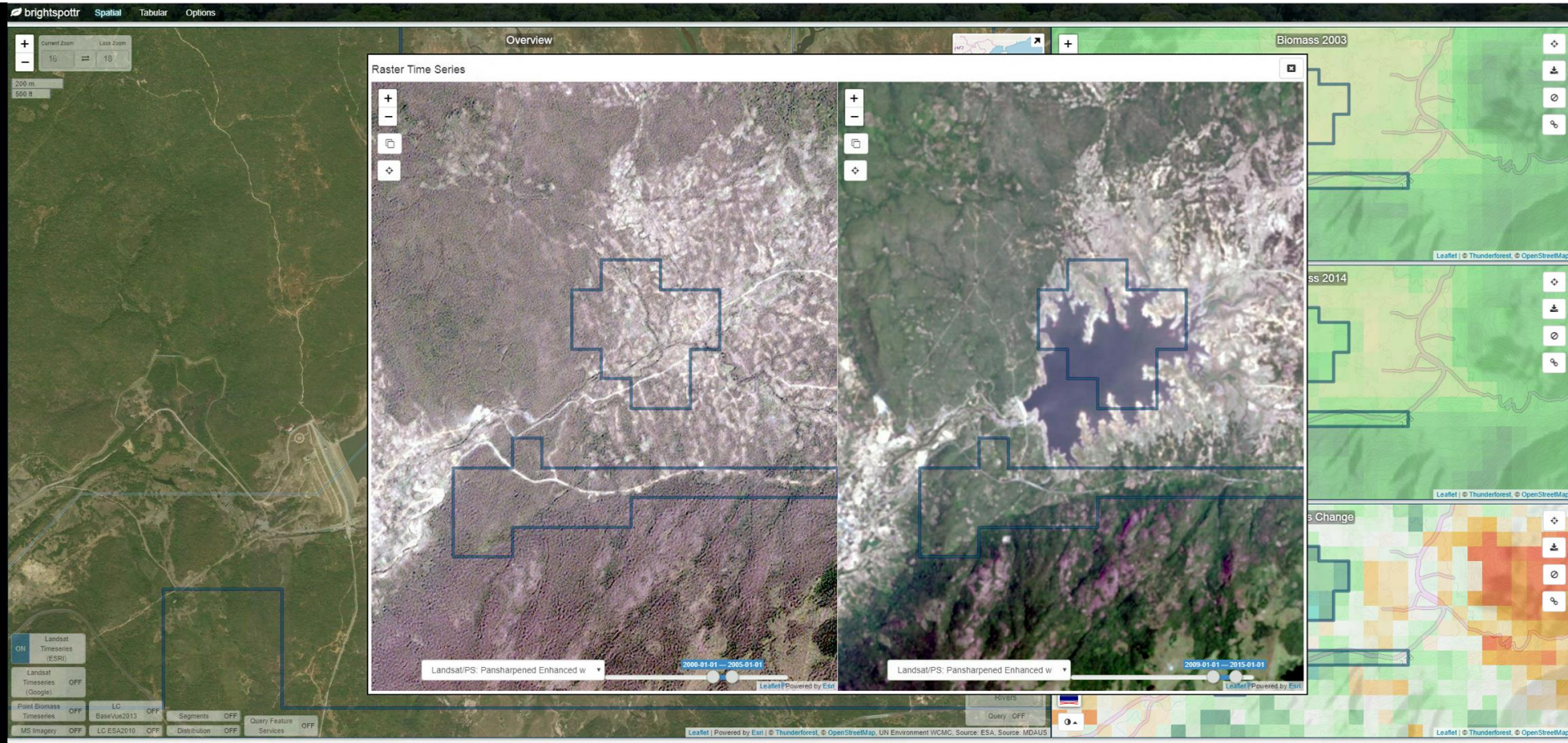
driver_id	location	bearing	from	to	transition	confidence	comments	pa	status	primary	from_old	to_old	trans_old	flags	matrix	Edit	Delete	Promote

No data available in table

Nifty R Packages

- Tidyverse:
  - tidyr, dplyr, magrittr, purrr, stringr, …etc
  - sf: simple features + tidyverse > Spatial*DataFrame
- Visualize:
  - leaflet (mapview, leaflet.extra, leaflet.esri)
- Database Trickery:
  - rpostgis
  - dbplot
- Query External Services:
  - crul, rjson
- Shiny Enhancements:
  - shinyjs, shinyjqui
- Asynchronous processing:
  - future, promises, callr, future.callr


brightspottr
Spatial
Tabular
Options
Overview
Biomass 2003
Biomass 2014
Biomass Change
Protected Areas
Managed Forests
Land Rights
Resource Rights
Rivers
Leaflet | Powered by Esri | © Thunderforest, © OpenStreetMap, Source: MDAUS, Source: ESA, UN Environment WCMC



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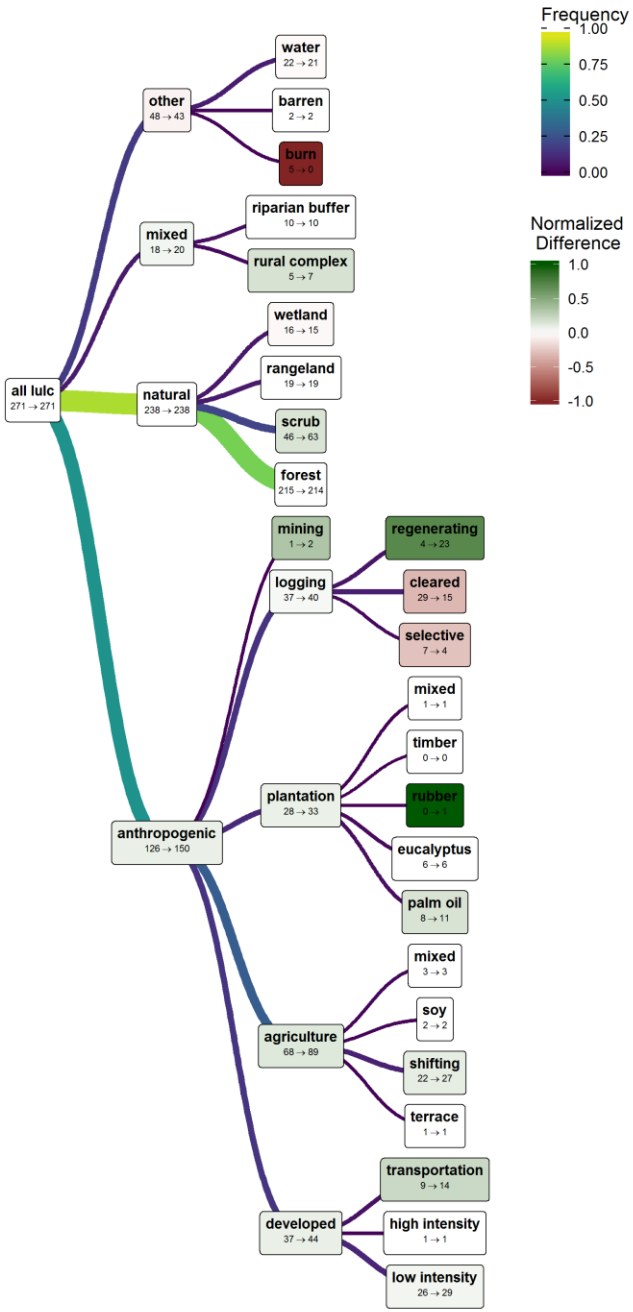
status	uid	change	cell_count	b03_mea	b14_mea	bch_mea	b03_med	b14_med	bch_med	b03_min	b14_min	bch_min	b03_max	b14_max	bch_max	country
Selected	Asia455411	gain	34	71.177	113.529	42.353	69.500	113.000	39.000	33	80	11	139	174	95	Vietnam
Activated	Asia455411	gain	34	71.177	113.529	42.353	69.500	113.000	39.000	33	80	11	139	174	95	Vietnam

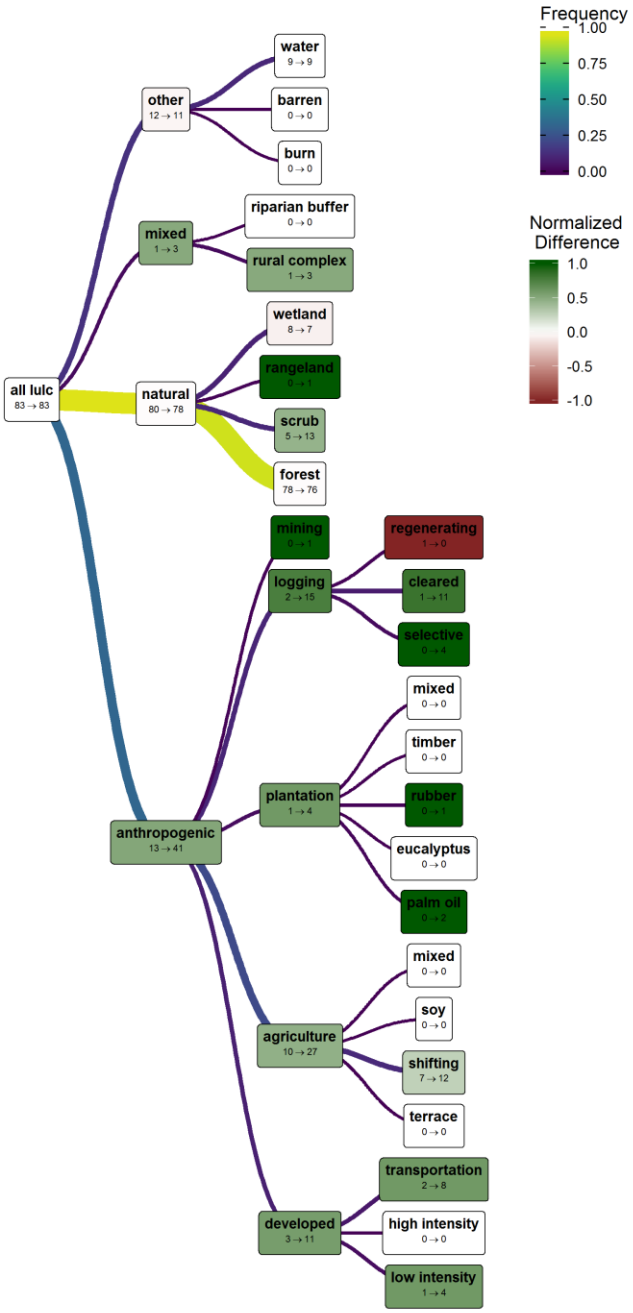
UID | Change | Driver ID | Location | Bearing | From | To | Transition | Matrix | Protected Area | Flags | Comments | Confidence | Status

Stop App + Close

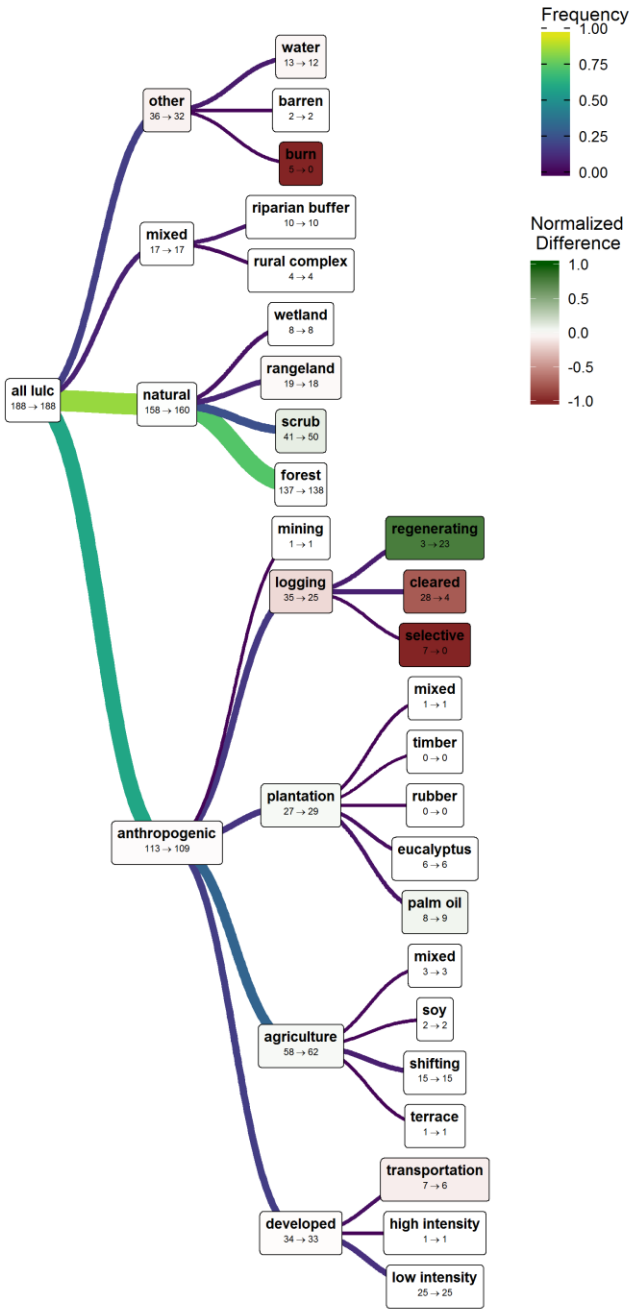
All Clusters



Loss Clusters: All



Gain Clusters: All



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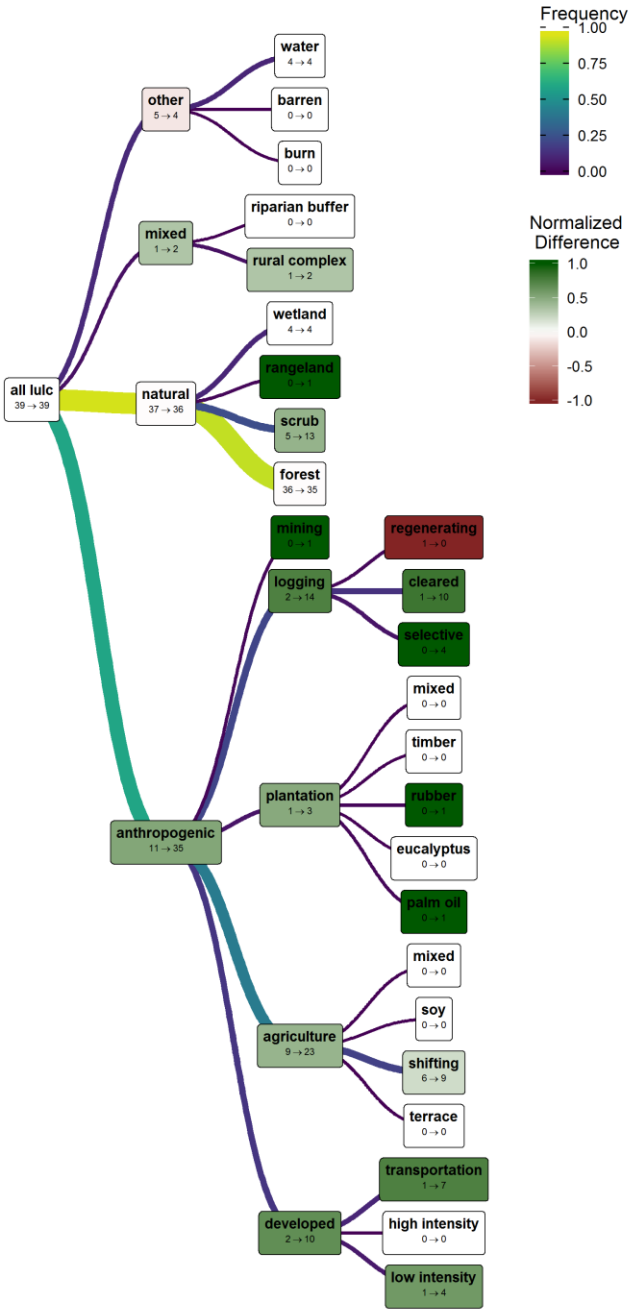
Loss Clusters: Anthropogenic Transitions



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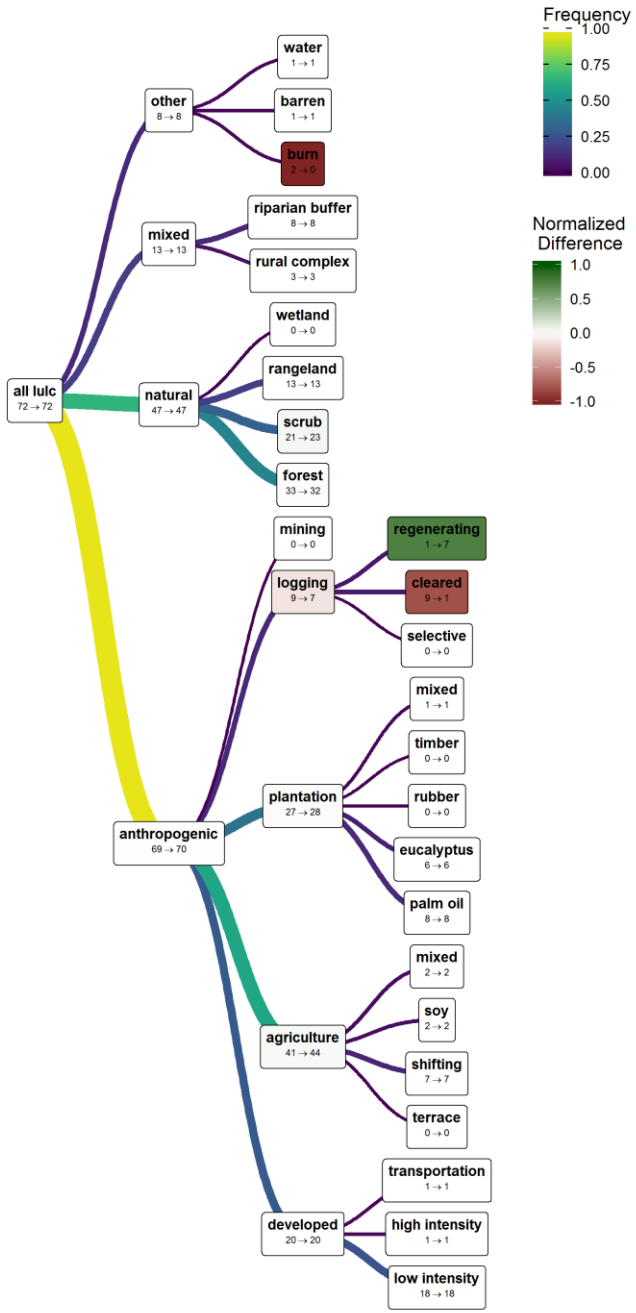
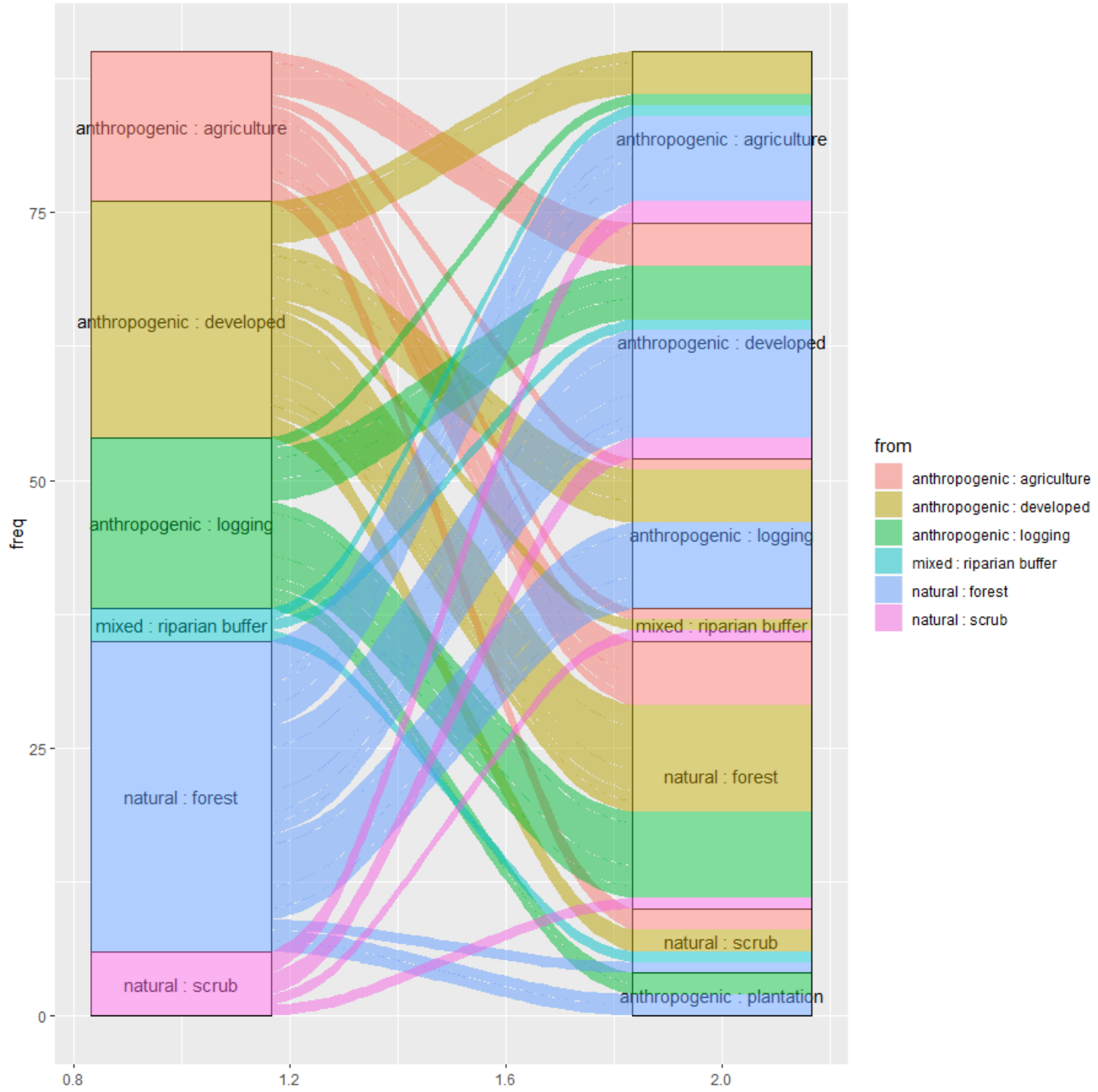
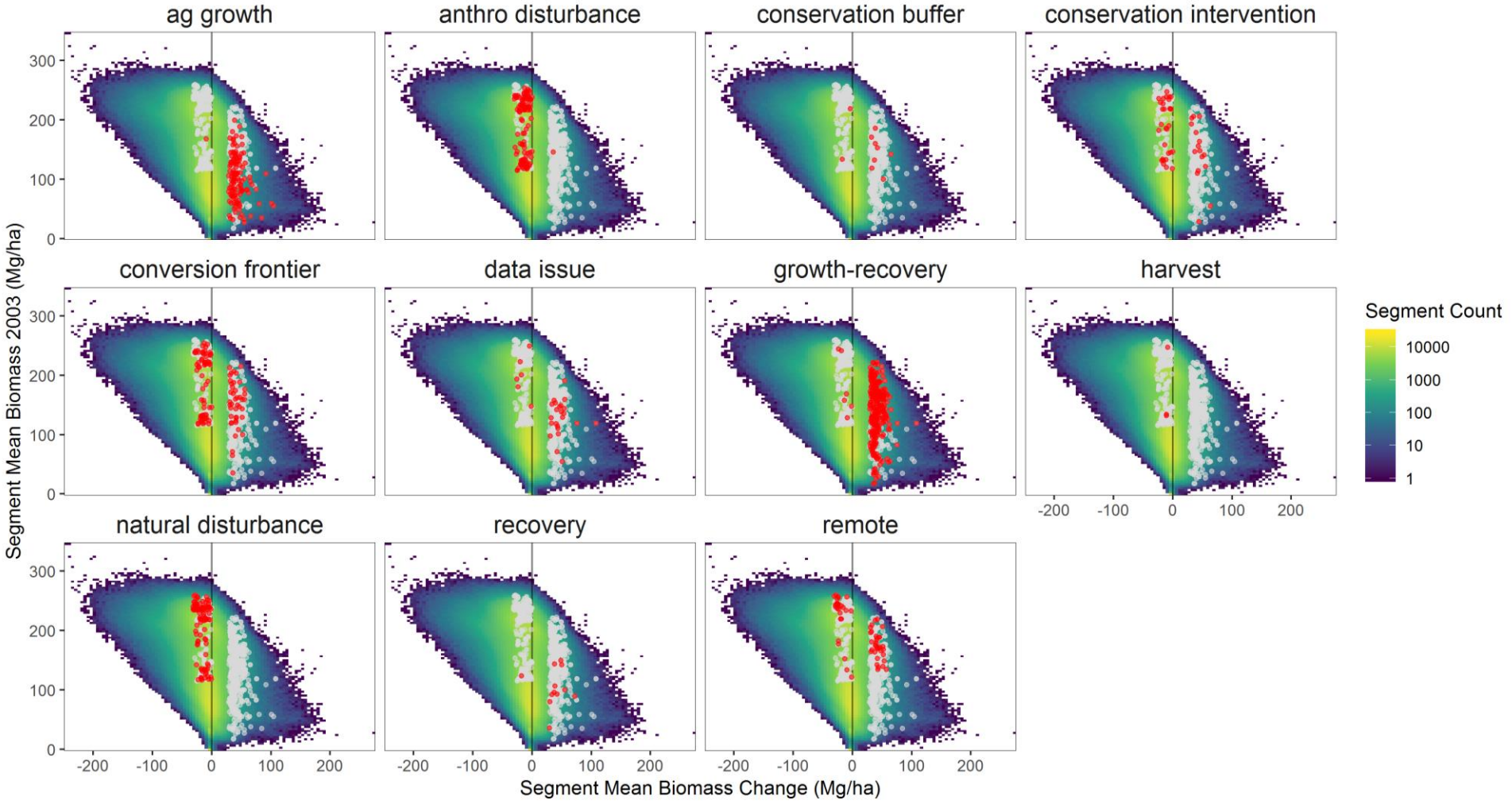



anthropogenic : agriculture
anthropogenic : developed
anthropogenic : logging
mixed : riparian buffer
natural : forest
natural : scrub
anthropogenic : agriculture
anthropogenic : developed
anthropogenic : logging
mixed : riparian buffer
natural : forest
natural : scrub
anthropogenic : plantation
freq
0
25
50
75
0.8
1.2
1.6
2.0
from
anthropogenic : agriculture
anthropogenic : developed
anthropogenic : logging
mixed : riparian buffer
natural : forest
natural : scrub


ag growth
anthro disturbance
conservation buffer
conservation intervention
conversion frontier
data issue
growth-recovery
harvest
natural disturbance
recovery
remote
Segment Mean Biomass 2003 (Mg/ha)
Segment Mean Biomass Change (Mg/ha)
Segment Count
10000
1000
100
10
1
0
100
200
300
-200
-100
0
100
200