

# Land cover and forest change

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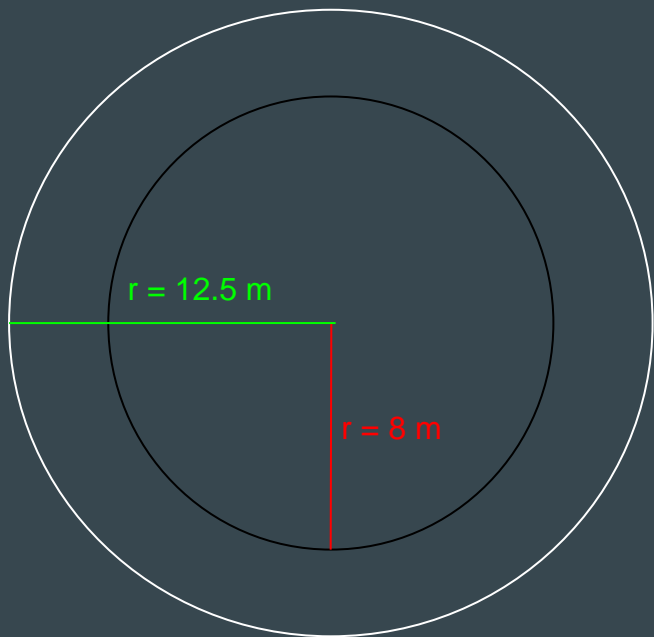
# Contents

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- Results and Discussion: Species richness, Shannon diversity and plant communities
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- Vegetation trends in rubber plantations

# Overview of Nayang tai

- ❑ Tai Lue people, 112 households.
- ❑ Hmong people, 30-40 households.
- ❑ Religion: mostly believe in Buddhism.
- ❑ Livelihood: Handicraft-bases production, Since 2000.
- ❑ Rubber plantation since 2006.
- ❑ Tourism in 2018.
- ❑ Forest type: Mixed forest.

# Plot design and data collection



- DBH was measure at breast height; 1.3 m.
- Inner circle ( $r=8$  m) :  $8 \leq \text{DBH} \leq 24.9$  cm.
- Outer circle ( $r=12.5$  m) :  $\text{DBH} \geq 25$  cm.
- Bamboo clumps are counted.

## Plot nomenclature

- E = Early successional, <15 years
- I = Intermediate, 15-20 years
- L = Late successional, >20 years
- P = Plantation (rubber) only

Area of 8 m circle = 201 m<sup>2</sup>

Area of 12.5 m circle = 409 m<sup>2</sup>

# Plot locations

No. of surveyed plots:

6 Early

7 Intermediate

11 Late

6 Plantations

Total: 30 plots

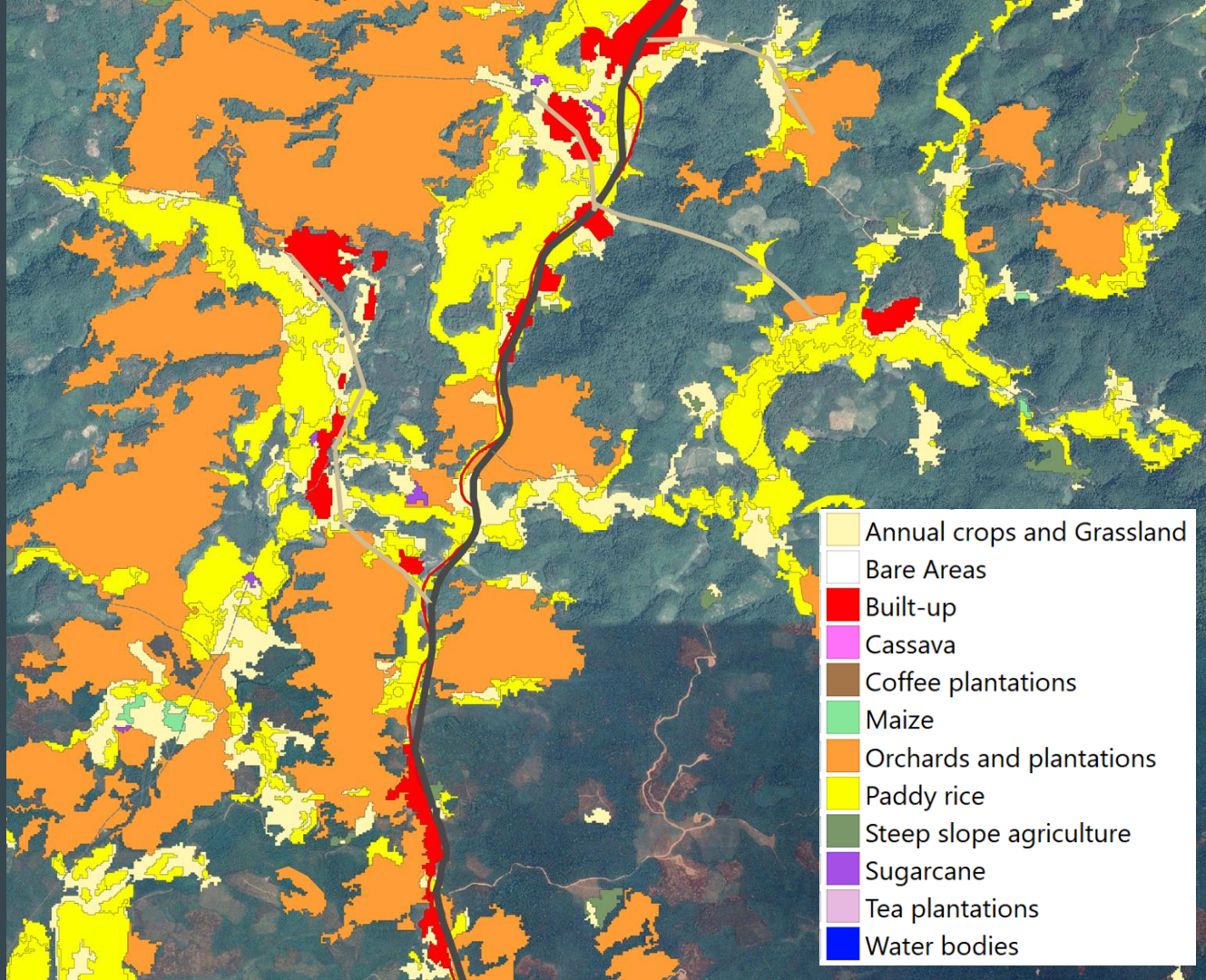




# Land cover

Data sourced from the  
Laos Land Resources  
Information  
Management System,  
by DALaM.

Data is for 2019.



## Plot data: Early succession

Row Labels	Number of trees	Number of species	Canopy cover (%)	No. of bamboo clusters	Elevation
Early					
E2	4	3	76.0	14	415
E3	5	5	84.6	13	430
E4	9	7	90.1	29	445
E5	14	10	89.8	9	456
E6	7	6	89.1	12	427
E7	3	3	84.4	18	444
Subtotal	42	27	85.7 (mean)	95	436 (mean)

## Plot data: Intermediate succession

Row Labels	Number of trees	Number of species	Canopy cover (%)	No. of bamboo clusters	Elevation
Intermediate					
I1	13	9	84.4	17	421
I2	1	1	83.1	12	445
I3	16	10	87.8	10	468
I4	7	6	84.4	7	473
I5	14	10	79.7	12	475
I6	9	6	78.1	17	464
I7	12	11	93.5	11	458
I8	8	6	86.5	16	443
Subtotal	80	38	84.7 (mean)	102	456 (mean)



## Plot data: Late succession

Row Labels	Number of trees	Number of species	Canopy cover (%)	No. of bamboo clusters	Elevation
Late					
L1	13	10	86.7	13	428
L2	12	8	90.9	13	429
L3	8	7	88.8	10	438
L4	22	13	90.6	20	458
L5	18	7	86.2	30	464
L6	9	5	77.6	13	458
L7	5	3	89.8	19	473
L8	11	8	81.0	23	486
L9	4	4	82.0	16	492
L10	12	5	81.8	24	502
L11	20	10	79.2	11	511
Subtotal	134	44	85.0 (mean)	192	467 (mean)

## Plot data: Plantation

Row Labels	Number of trees	Number of species	Canopy cover (%)	No. of bamboo clusters	Elevation
Plantation					
P1	34	1	100.0	0	389
P2	17	1	100.0	0	405
P3	36	1	100.0	0	395
P4	26	1	100.0	0	396
P5	34	1	100.0	0	401
P6	30	1	100.0	0	383
Subtotal	177	1	100.0 (mean)	0	395

Plot	Top 3 abundant	Number of tree	Top 3 species with highest basal area	basal area m <sup>2</sup>
Early	ดอกกิบเก้า (Dok Kib Kao)	6	ปอขาว (Por Kaw)	9518.1
	<i>Polyalthia sp.1</i>	4	ดอกกิบเก้า (Dok Kib Kao)	9085.9
	ปอขาว (Por Kaw)	3	<i>Semecarpus cochinchinensis</i>	8666.2
	<i>Pterospermum megalocarpum</i>	3		
Intermediate	<i>Polyalthia sp.2</i>	6	<i>Ficus sp.2</i>	42103.7
	<i>Canarium sp.</i>	5	<i>Canarium sp.</i>	15934.1
	<i>Alstonia rostrata</i>	5	<i>Polyalthia sp.2</i>	10418.9
	<i>Polyalthia sp.1</i>	5		
Late	<i>Alstonia rostrata</i>	20	<i>Alstonia rostrata</i>	93744.7
	<i>Nephelium hypoleucum</i>	13	หมากเงือก	25184.6
	ไม้ขาว (Mai Ka Haw)	12	ปีป	22534.1

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
E2	<i>Engelhardtia sp.</i>	1668.6	<i>Engelhardtia sp.</i>	2
	ปอขาว	709.2		
	ไม้ใบปิ่น	244.2		
E3	ปีกแห้ง	1604.6	No dominant	
	<i>Alstonia rostrata</i>	1100.6		
	<i>Markhamia stipulata</i>	355.1		
E4	ปอขาว	8809.0	ปอขาว	2
	ปีกแห้ง	6373.4	ดอกกิบเก้า	2
	ดอกกิบเก้า	6182.8		

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
E5	หมากหมุน	3195.9	ดอกก๊ีบเก๋า	3
	ไม้ก้านยาว	3057.1	<i>Polyalthia sp.1</i>	2
	ตังเลี่ยน	2982.7	<i>Pterospermum megalocarpum</i>	2
E6	หนังกลอง	4556.1	หนังกลอง	2
	หมากไฟ	621.9		
	<i>Pterospermum megalocarpum</i>	336.2		
E7	<i>Semecarpus cochinchinensis</i>	8666.2	No dominant	
	ไต่ไก่อ	3100.9		
	<i>Cinamomum iners</i>	2192.9		

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
I1	<i>Ficus sp.2</i>	42103.7	จวง	2
	ไม้หาด	7716.8	<i>Canarium sp.</i>	2
	<i>Polyalthia sp.1</i>	7089.2	<i>Ficus sp.2</i>	2
			<i>Polyalthia sp.1</i>	2
I2	<i>Alstonia rostrata</i>	1048.8	No dominant	
I3	<i>Canarium sp.</i>	9683.3	<i>Polyalthia sp.2</i>	5
	<i>Polyalthia sp.2</i>	9651.5	<i>Nephelium hypoleucum</i>	2
	<i>Knema sp.1</i>	1926.7	<i>Canarium sp.</i>	2
I4	ไม้ขี้	2607.1	<i>Knema sp.2</i>	2
	<i>Knema sp.2</i>	2506.9		
	<i>Stereospermum neuranthum</i>	2230.0		



Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
I5	<i>Lagerstroemia sp.</i>	7846.2	<i>Ficus sp.4</i>	3
	ไม้พอง	4093.4	<i>Nephelium hypoleucum</i>	2
	<i>Ficus sp.4</i>	2579.2	<i>Pterospermum megalocarpum</i>	2
I6	<i>Alstonia rostrata</i>	2694.7	<i>Polyalthia sp.1</i>	2
	<i>Wrightia arborea</i>	2354.3	นางเขีย	2
	นางเขีย	981.2	<i>Alstonia rostrata</i>	2
I7	หนังกลอง	6292.6	ไม้พอง	2
	<i>Knema sp.1</i>	3893.8		
	ไม้พอง	2475.3		

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
I8	ดอกปีด	2052.5	จำส้าน	3
	<i>Lithocarpus sp.</i>	1515.5		
	<i>Alstonia rostrata</i>	1247.4		
L1	ปอขาว	4283.3	<i>Wrightia arborea</i>	2
	<i>Myristicaceae sp.</i>	3170.5	ไม้ซ้าหา	2
	<i>Wrightia arborea</i>	2958.9	<i>Pterospermum megalocarpum</i>	2
L2	<i>Alstonia rostrata</i>	13875.2	<i>Polyalthia sp.2</i>	3
	หมากเคื้อม	2995.0	<i>Alstonia rostrata</i>	3
	<i>Syzygium sp.</i>	2124.7		

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
L3	ทะโล้	15583.0	ทะโล้	2
	<i>Engelhardtia sp.</i>	827.9		
	ปีป่า	484.2		
L4	<i>Alstonia rostrata</i>	44649.3	<i>Alstonia rostrata</i>	7
	หมากเคี่ยม	3922.0	<i>Castanopsis ceratacantha</i>	3
	<i>Nephelium hypoleucum</i>	3318.3	นางเหี่ยว	2
L5	<i>Alstonia rostrata</i>	29854.3	<i>Alstonia rostrata</i>	8
	ปีป่า	15427.2	ปีป่า	4
	แฮกโยง	14401.1	<i>Nephelium hypoleucum</i>	2

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
L6	หมากเกี๋ยม	13835.3	หมากเกี๋ยม	3
	<i>Ficus sp.2</i>	12029.6	ไม้ชะหา	2
	ปีป่า	3193.8	ปีป่า	2
L7	<i>Wrightia arborea</i>	5306.1	<i>Wrightia arborea</i>	3
	หมากก้าม	2723.6		
	<i>Garcinia sp.</i>	2052.5		
L8	<i>Alstonia rostrata</i>	5366.0	<i>Castanopsis indica</i>	2
	หมากเกี๋ยม	4432.3	ไม้ชะหา	2
	ก้อกาสั่ง	1613.7	<i>Alstonia rostrata</i>	2

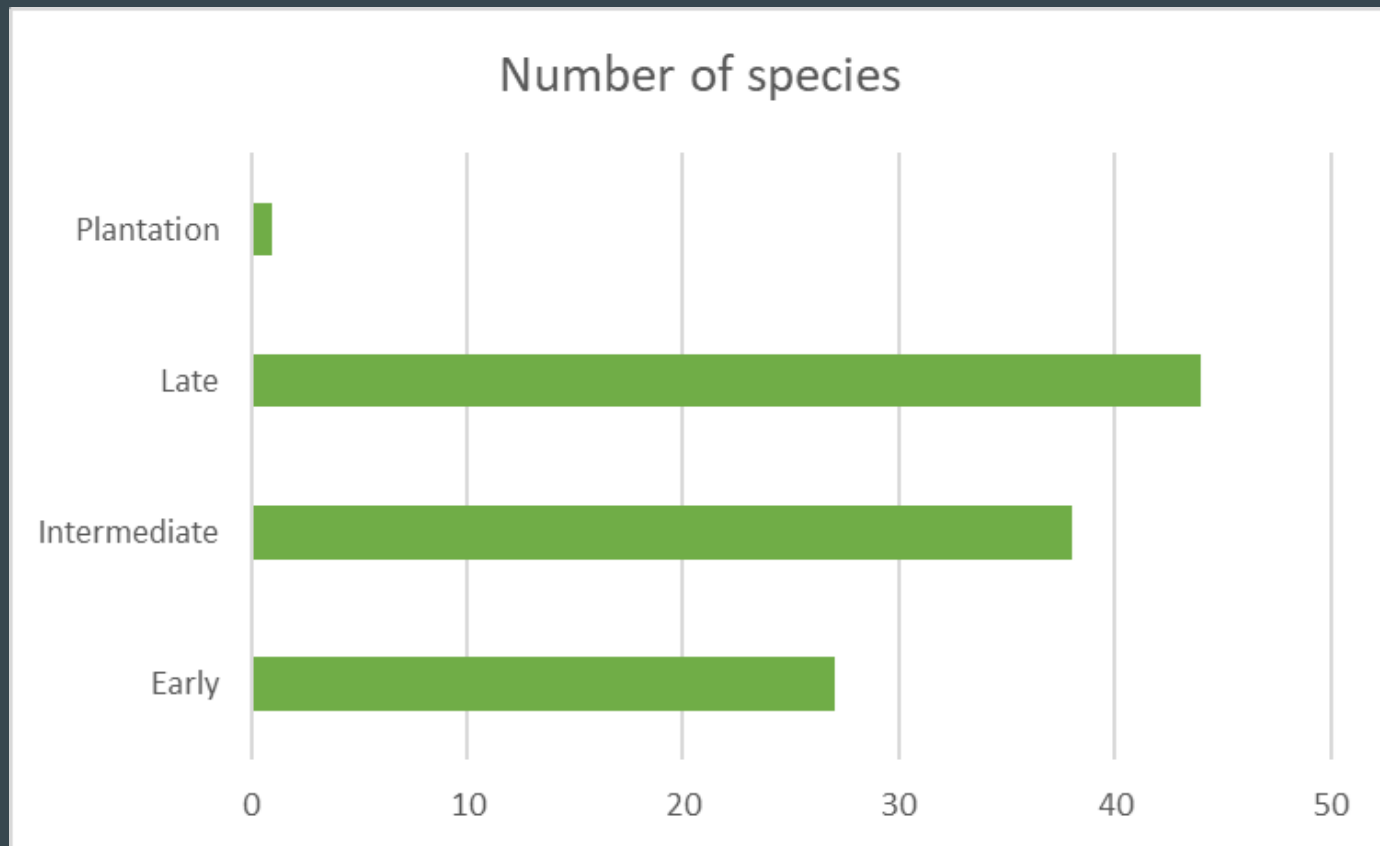
Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
L9	<i>Alstonia scholaris</i>	3922.0	No dominant	
	ขี้ป่า	3285.8		
	<i>Nephelium hypoleucum</i>	2305.3		
L10	<i>Castanopsis indica</i>	5217.3	<i>Nephelium hypoleucum</i>	5
	หมากมุ่น	4637.4	ไม้ซ้าหา	3
	<i>Nephelium hypoleucum</i>	2364.8	<i>Castanopsis indica</i>	2
L11	<i>Polyalthia sp. 1</i>	20065.1	<i>Polyalthia sp. 1</i>	6
	หมี่คำ	10222.0	ไม้ซ้าหา	3
	<i>Engelhardtia sp.</i>	9803.6	<i>Cinamomum iners</i>	2
			<i>Engelhardtia sp.</i>	2
			ไต่โค	2

Plot	Top 3 species with highest basal area	basal area m <sup>2</sup>	Top 3 abundant in each plot	Number of tree
P1	<i>Hevea brasiliensis</i>	23898.2	No dominant	
P2	<i>Hevea brasiliensis</i>	21893.7	No dominant	
P3	<i>Hevea brasiliensis</i>	39076.8	No dominant	
P4	<i>Hevea brasiliensis</i>	41304.6	No dominant	
P5	<i>Hevea brasiliensis</i>	26811.1	No dominant	
P6	<i>Hevea brasiliensis</i>	31495.5	No dominant	



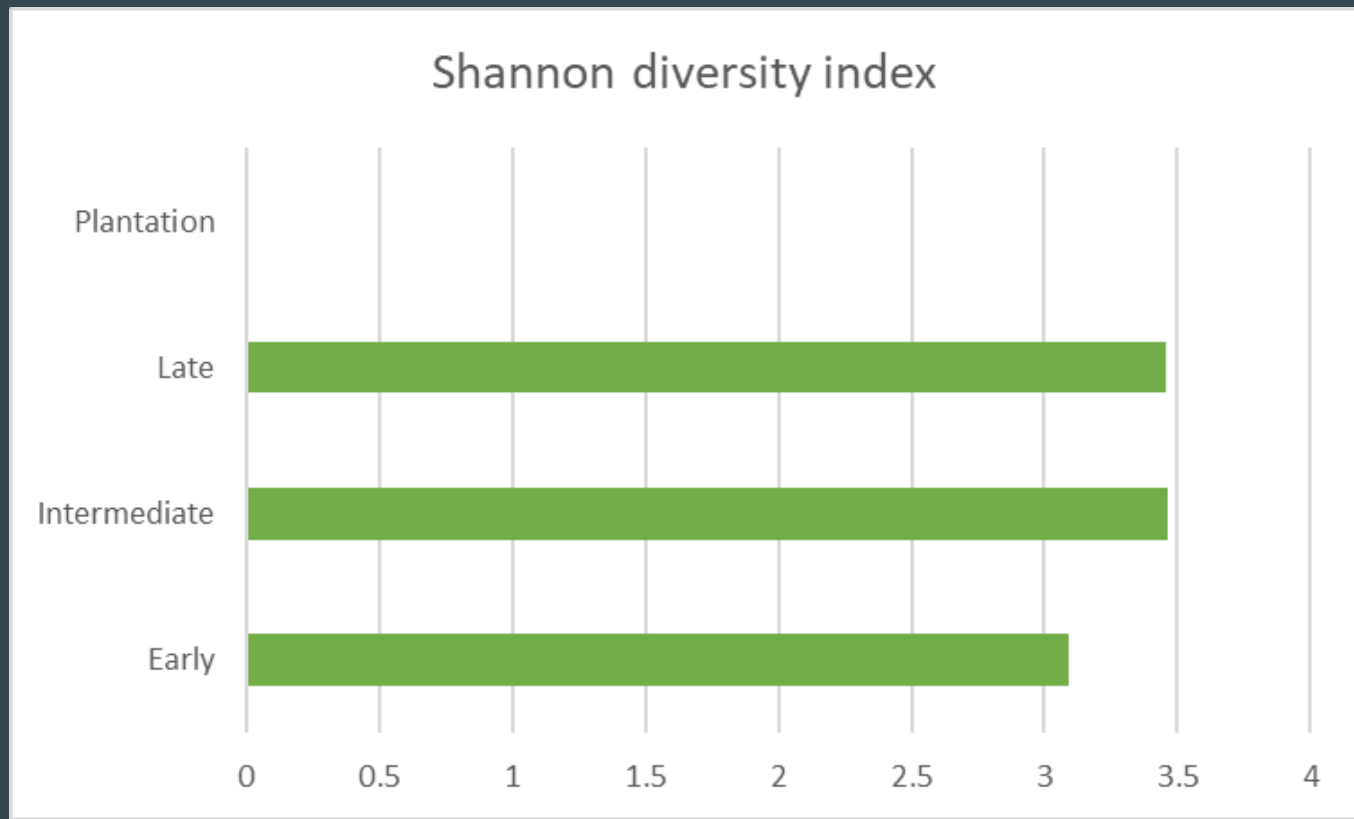
# Species richness

- Mean species richness was significantly different across forest types (AOV  $p = 0.00048^{***}$ )
- Total number of species 81



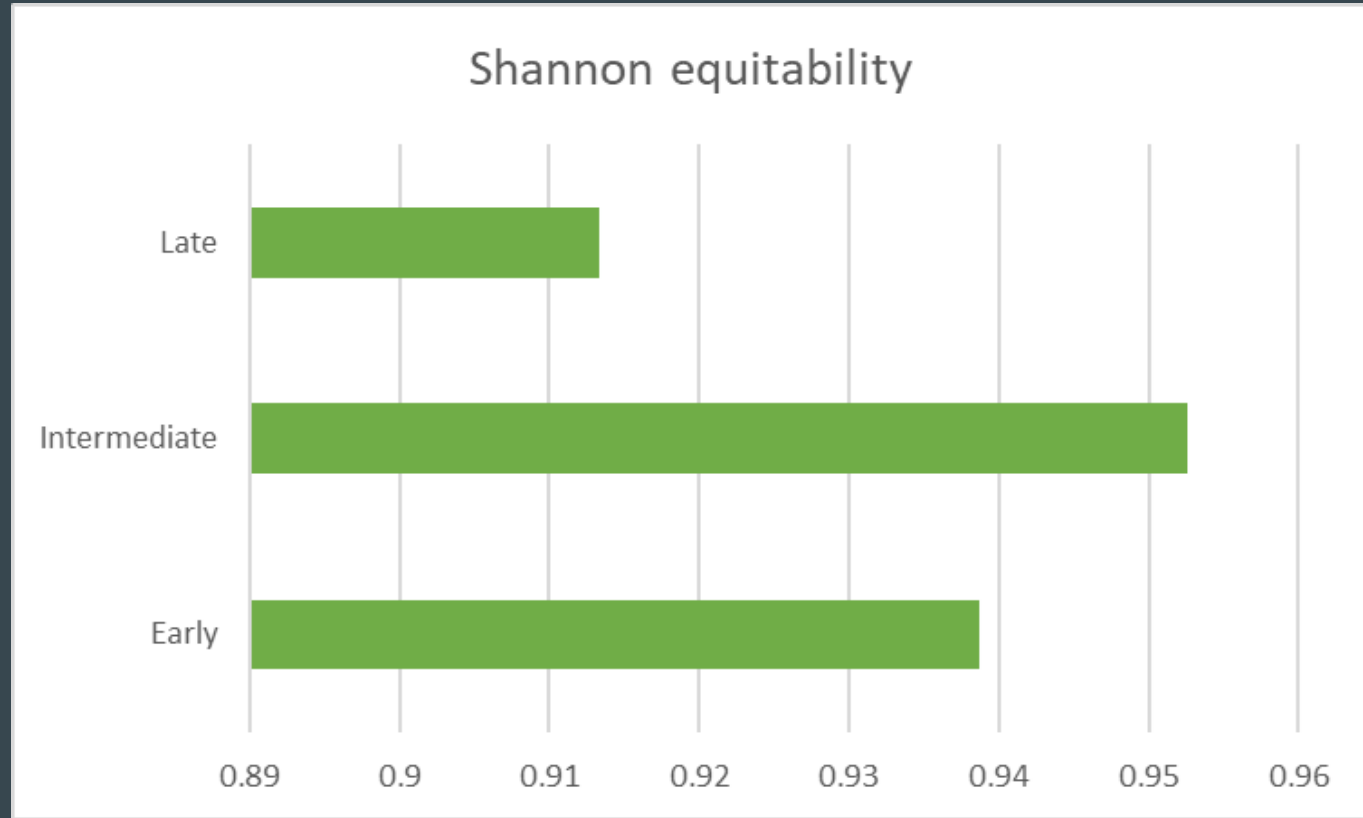
# Species diversity

- $H = -\sum p_i * \ln(p_i)$
- Significant difference in species diversity between forest types (AOV  $p = 6.78e-7^{***}$ )



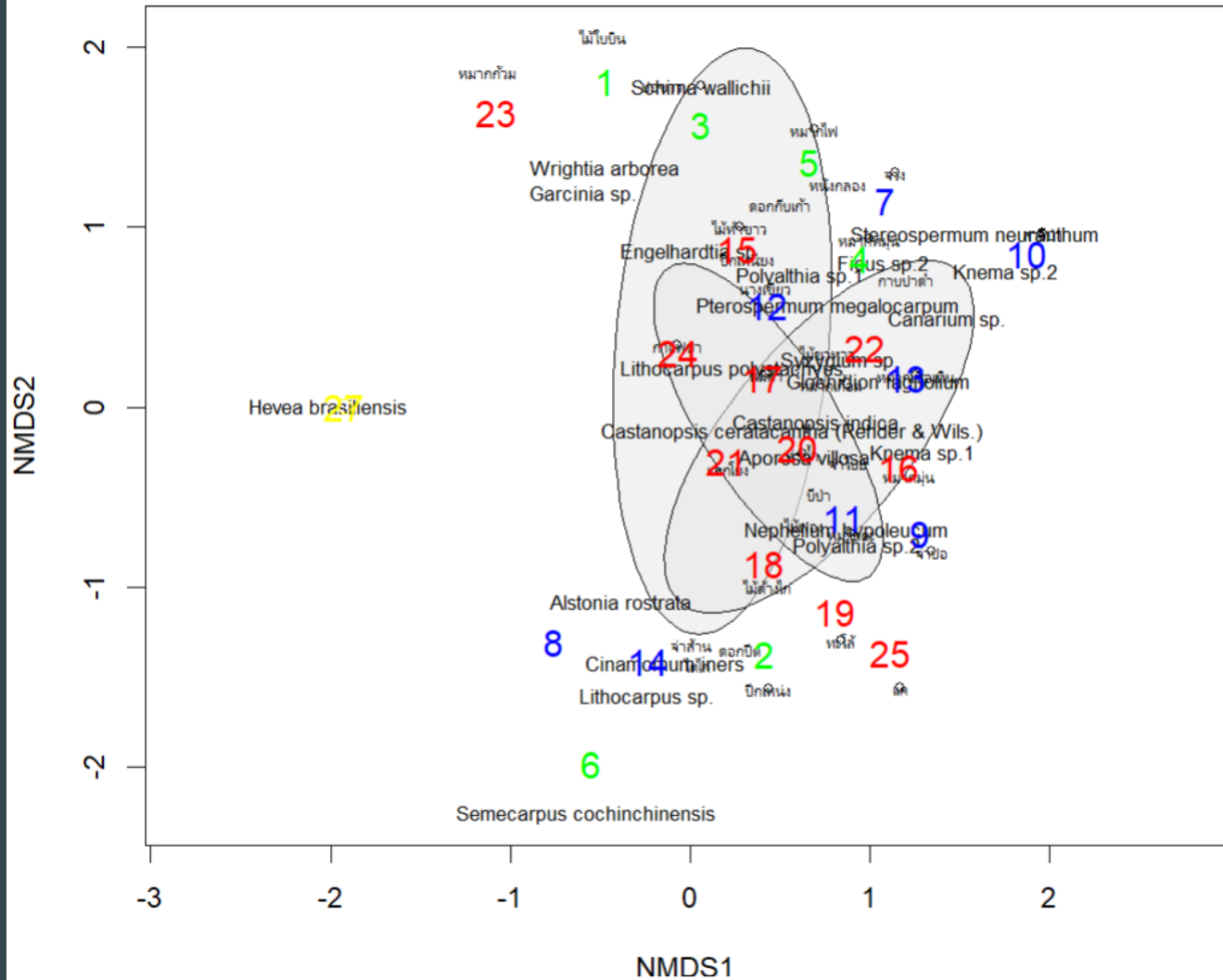
# Species evenness

- $EH = H/\ln(S)$



# Plant communities

- Plant communities differ by forest type (perMANOVA ( $p = 0.001^{***}$ ))
- NMDS clustering



# DBH, BA, AGB, and C across vegetation types

Type	Mean DBH (cm)	Mean Height (m)	Mean BA (m2)	Mean AGB (kg)	Mean C (kg)	Mean tree density (n/ha)	Total BA (m2)	Total AGB (kg)	Total C (kg)
E	19.4 ± 11.9	87.3 ± 31.7	1,619.1 ± 1,878.1	423.6 ± 628.9	199.1 ± 295.6	312 ± 168	68,001.1	17,791.0	8,361.8
I	20.6 ± 15.1	89.4 ± 36.6	2,044.7 ± 3,598.0	640.0 ± 1,651.9	300.8 ± 776.4	447 ± 210	163,577.2	51,201.8	24,064.8
L	21.2 ± 16.2	89.8 ± 39.7	2,227.5 ± 3,390.5	702.3 ± 1,386.0	330.1 ± 651.4	536 ± 250	298,490.1	94,104.7	44,229.2
P	17.8 ± 3.9	86.3 ± 11.1	1,042.3 ± 460.4	202.9 ± 118.9	95.4 ± 55.9	1447 ± 338	184,479.9	35,921.8	16,883.3

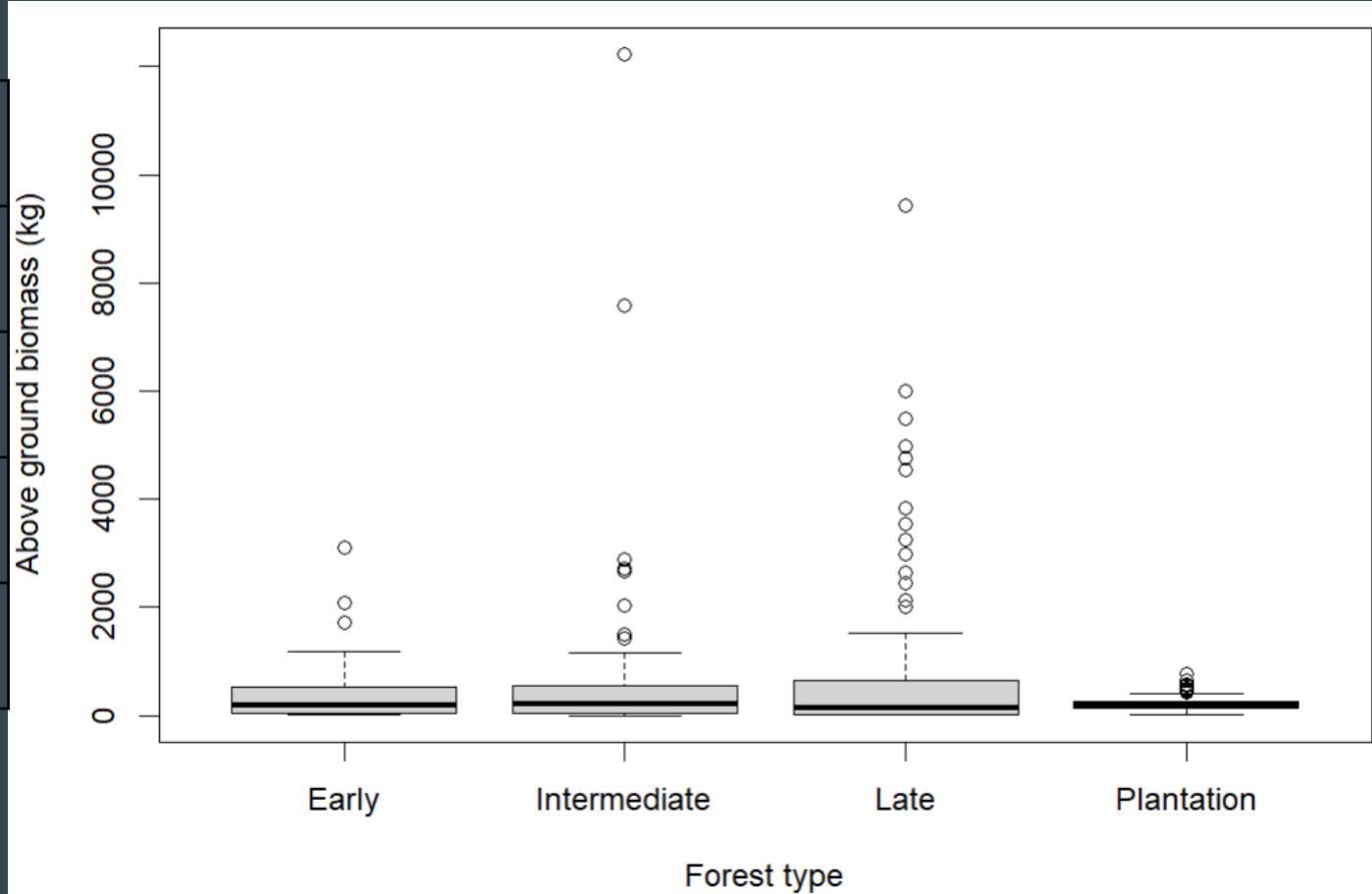
Height:  $\log(H) = 1.2156 + 0.5782 \times \log(\text{DBH})$ , from Feldspauch et al 2011

AGB =  $e^{(-2.289 + 2.649 \times \ln(\text{DBH}) - 0.021 \times \ln(\text{DBH})^2)}$ , from Pearson et al 2005

C fraction, taken as 47% of AGB, from Aalde et al 2006

# Aboveground biomass

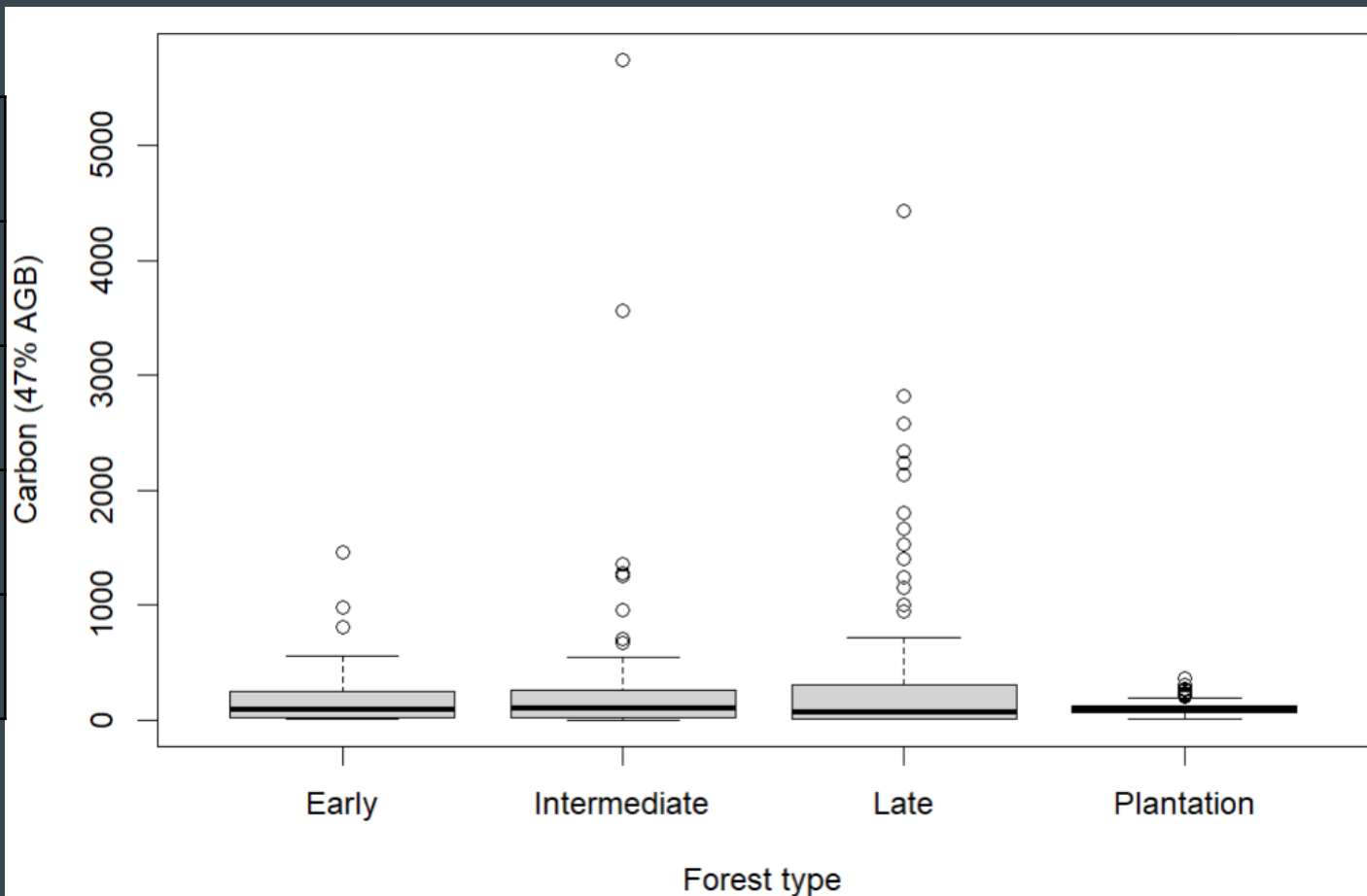
Type	Total AGB
Early	17,79 1.0
Intermediate	51,20 1.8
Late	94,10 4.7
Plantation	35,92 1.8





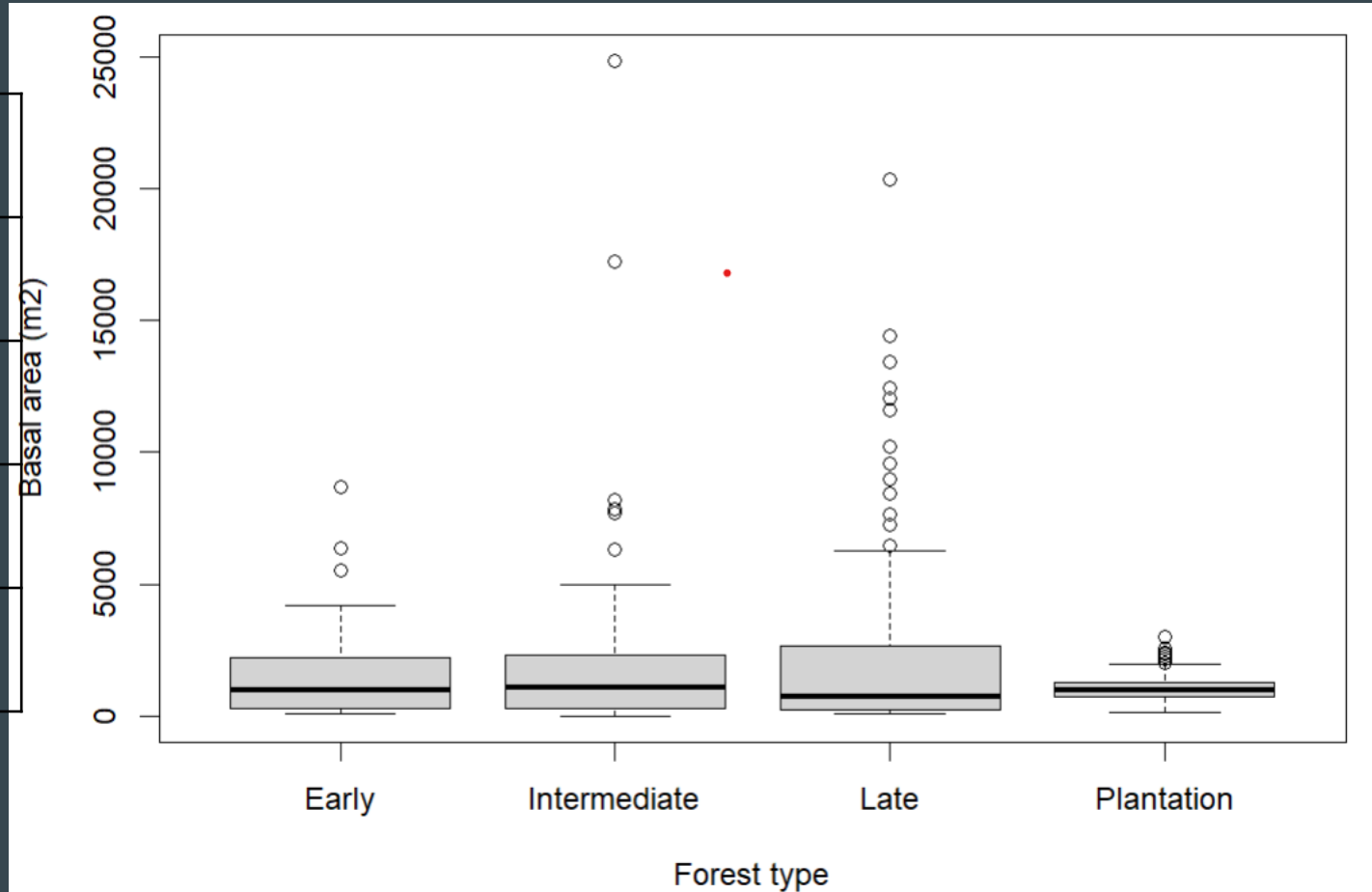
# Carbon content

Type	Total C
Early	8,36 1.8
Intermediate	24,0 64.8
Late	44,22 9.2
Plantation	16,88 3.3



# Basal area

Type	Total BA
Early	68,00 1.1
Intermediate	163,5 77.2
Late	298,4 90.1
Plantation	184,4 79.9

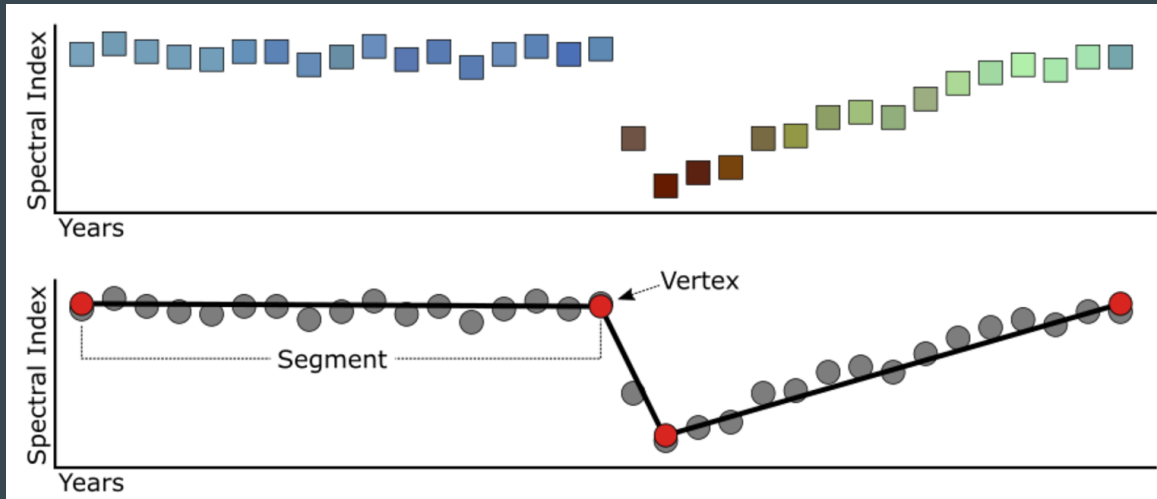


# Landtrendr

Google Earth Engine tool for understanding vegetation patterns over time.

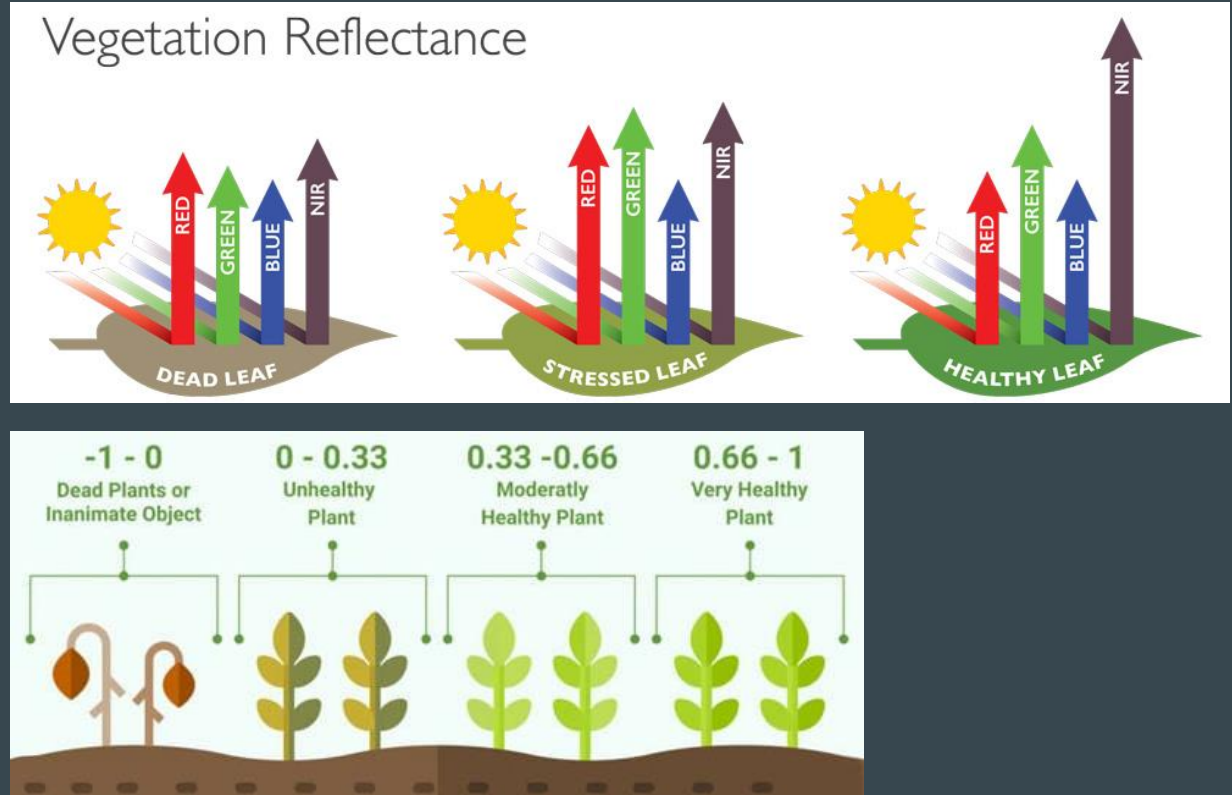
Contains 2 main functions: pixel time series plotter, and change mapper.

Relies on temporal segmentation of a vegetation index (e.g., NDVI).

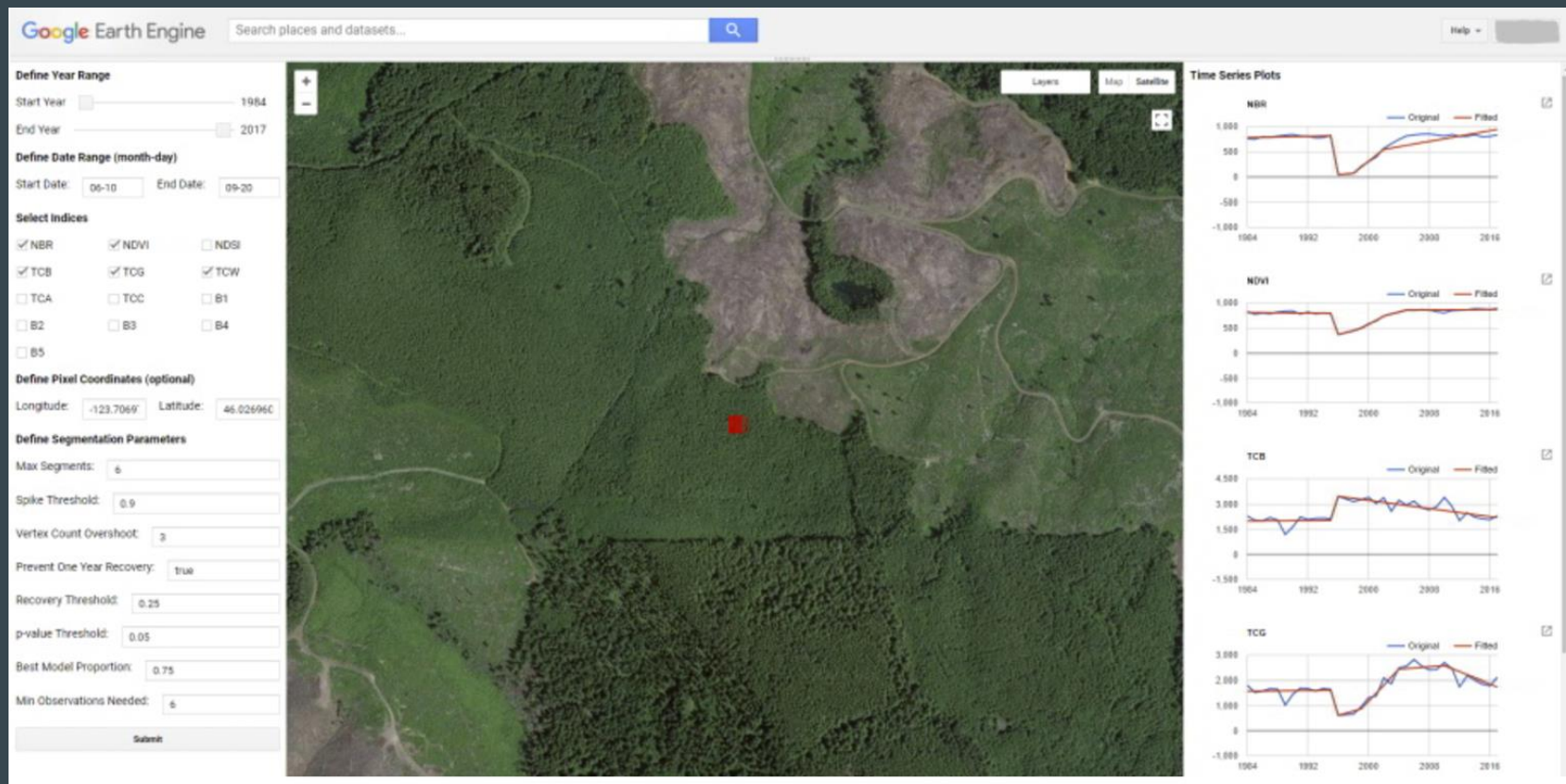


# Normalized Difference Vegetation Index (NDVI)

The NDVI index detects and quantifies the presence of live green vegetation using this reflected light in the visible and near-infrared bands.

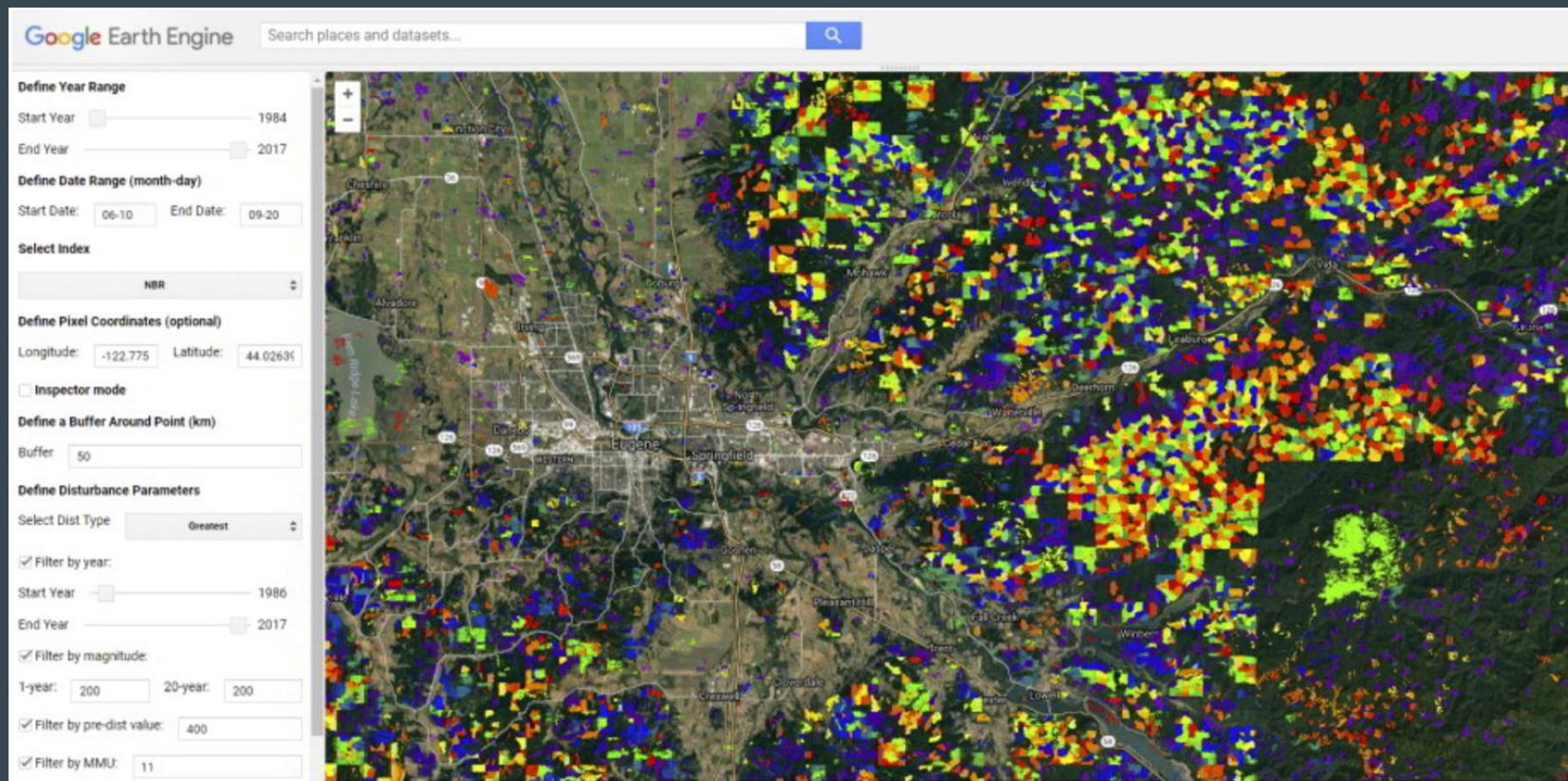


# Landtrendr: Pixel time series plotter



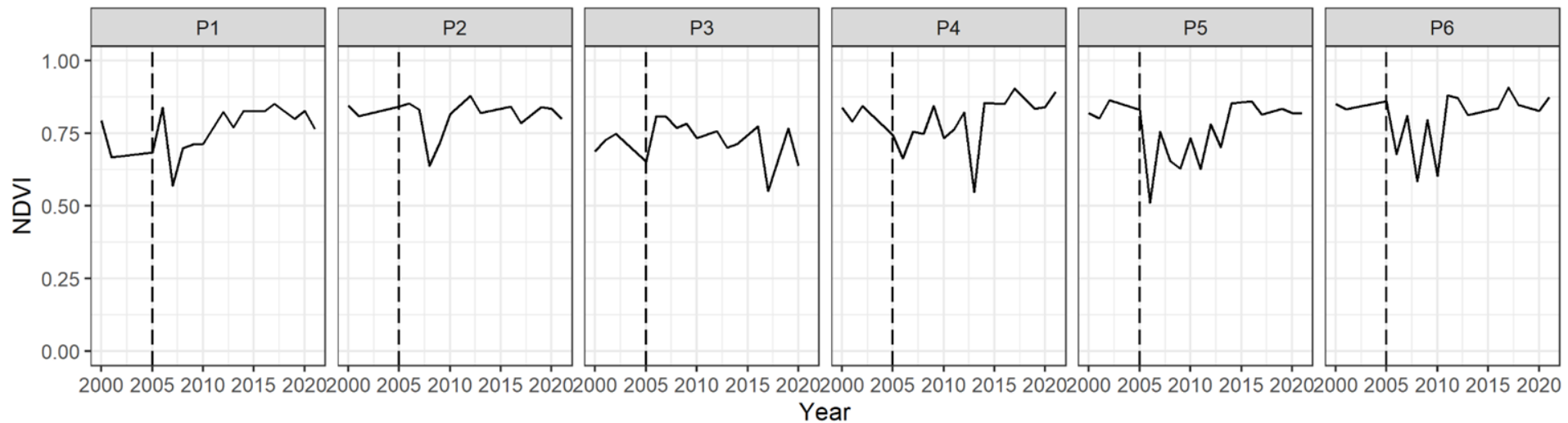


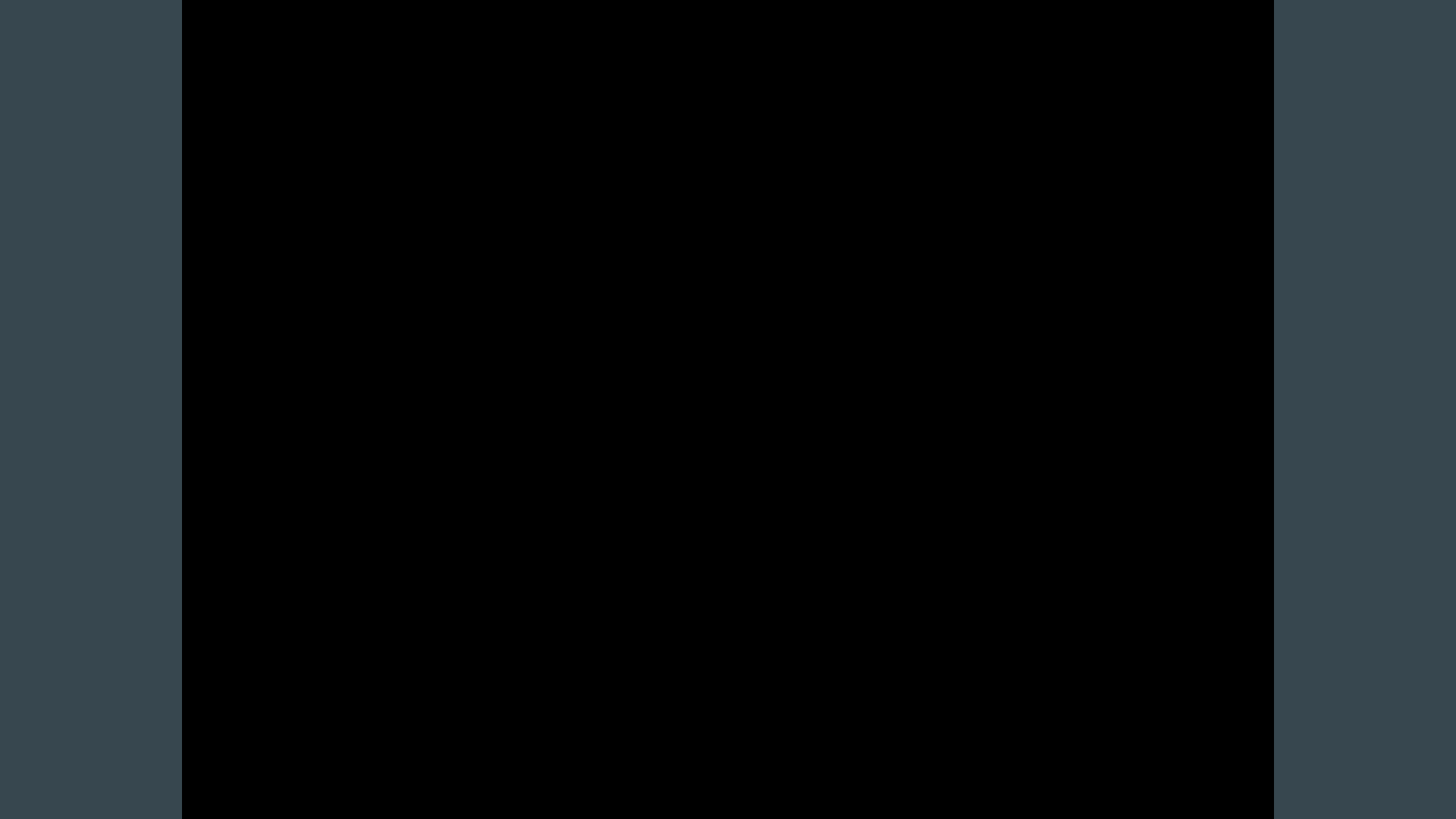
# Landtrendr: Change mapper



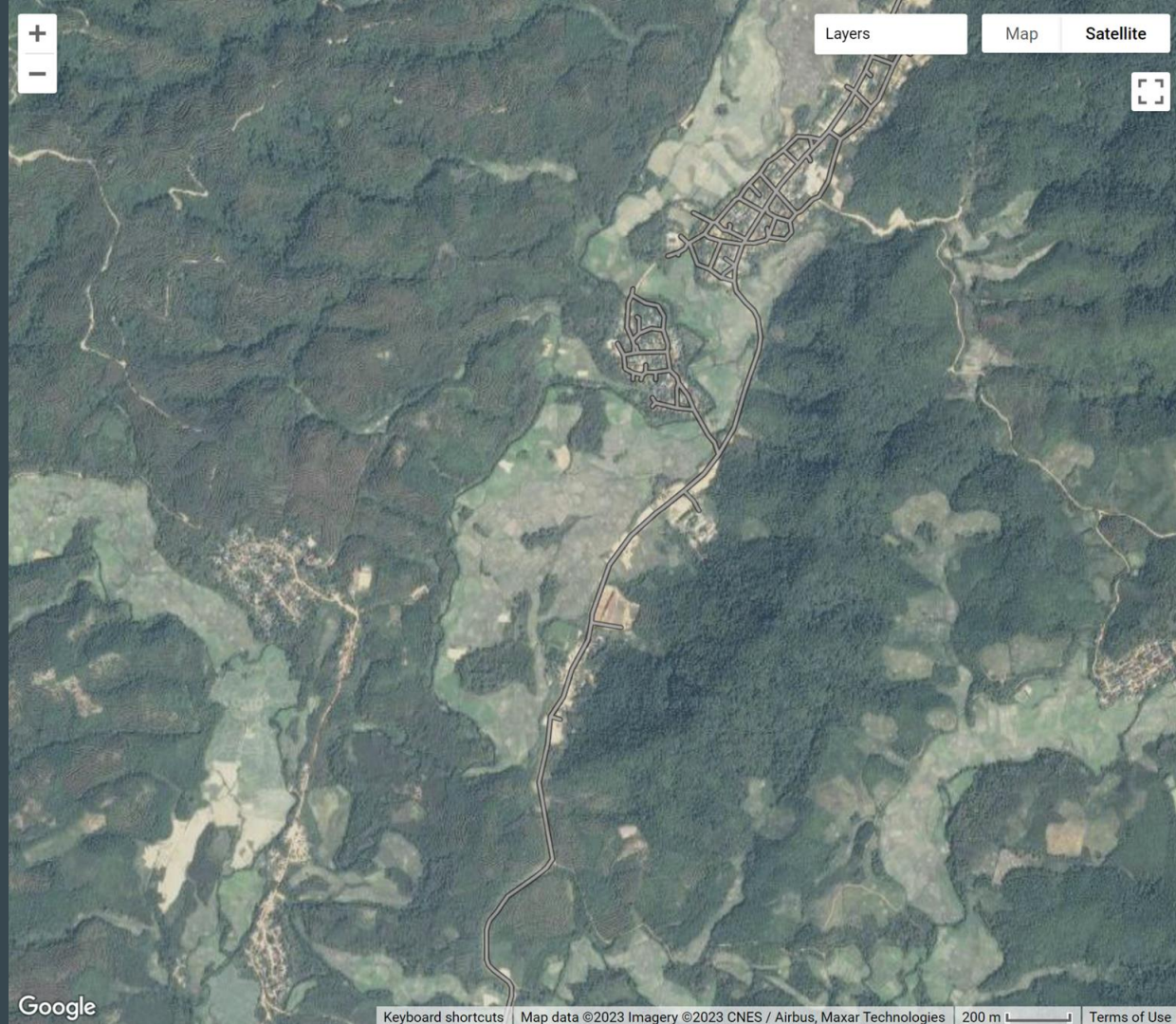


# NDVI annual time series profiles



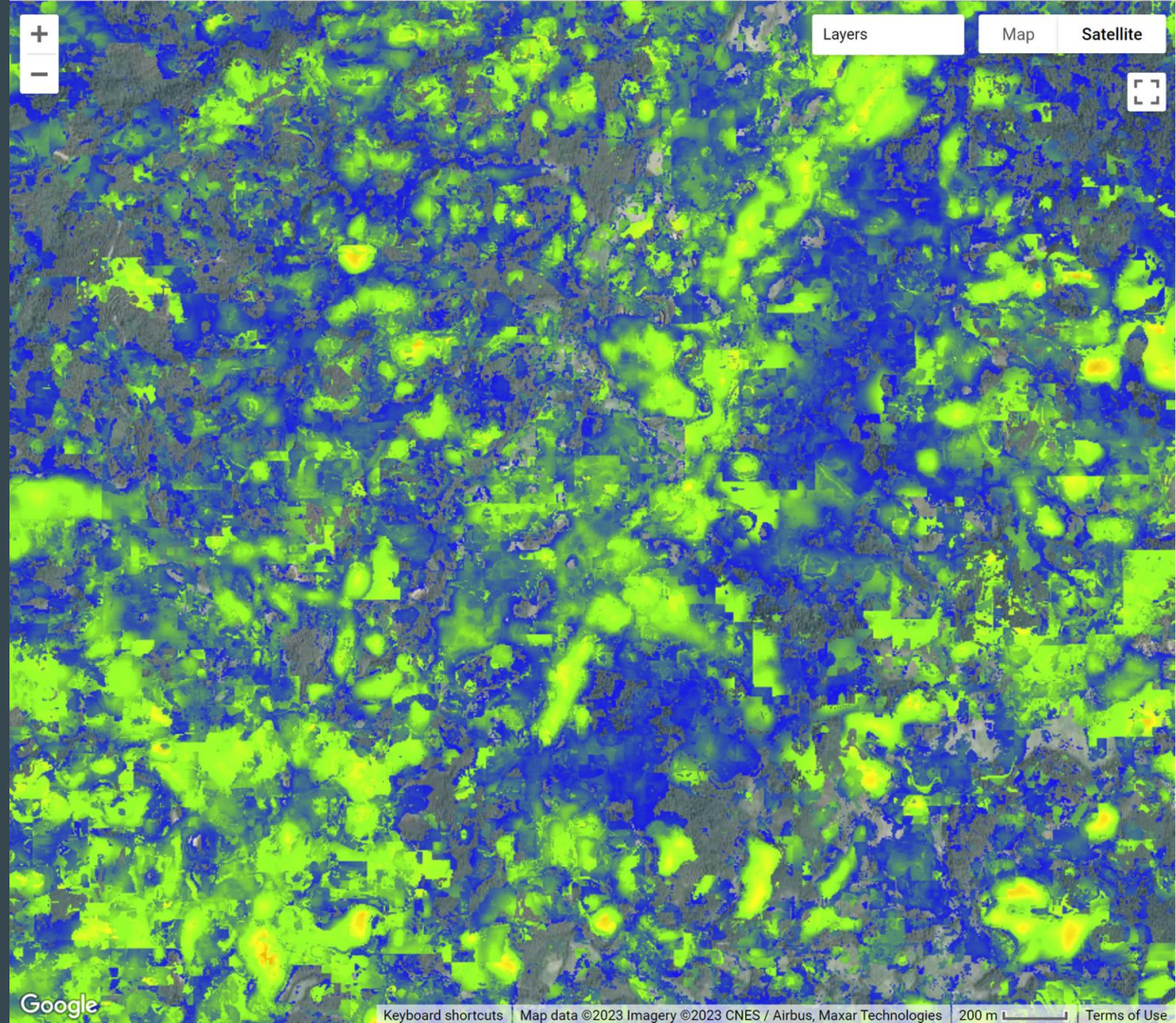
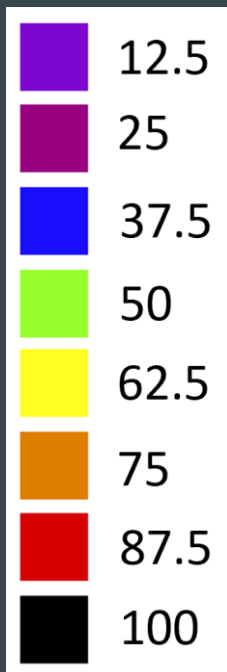


# Google basemap



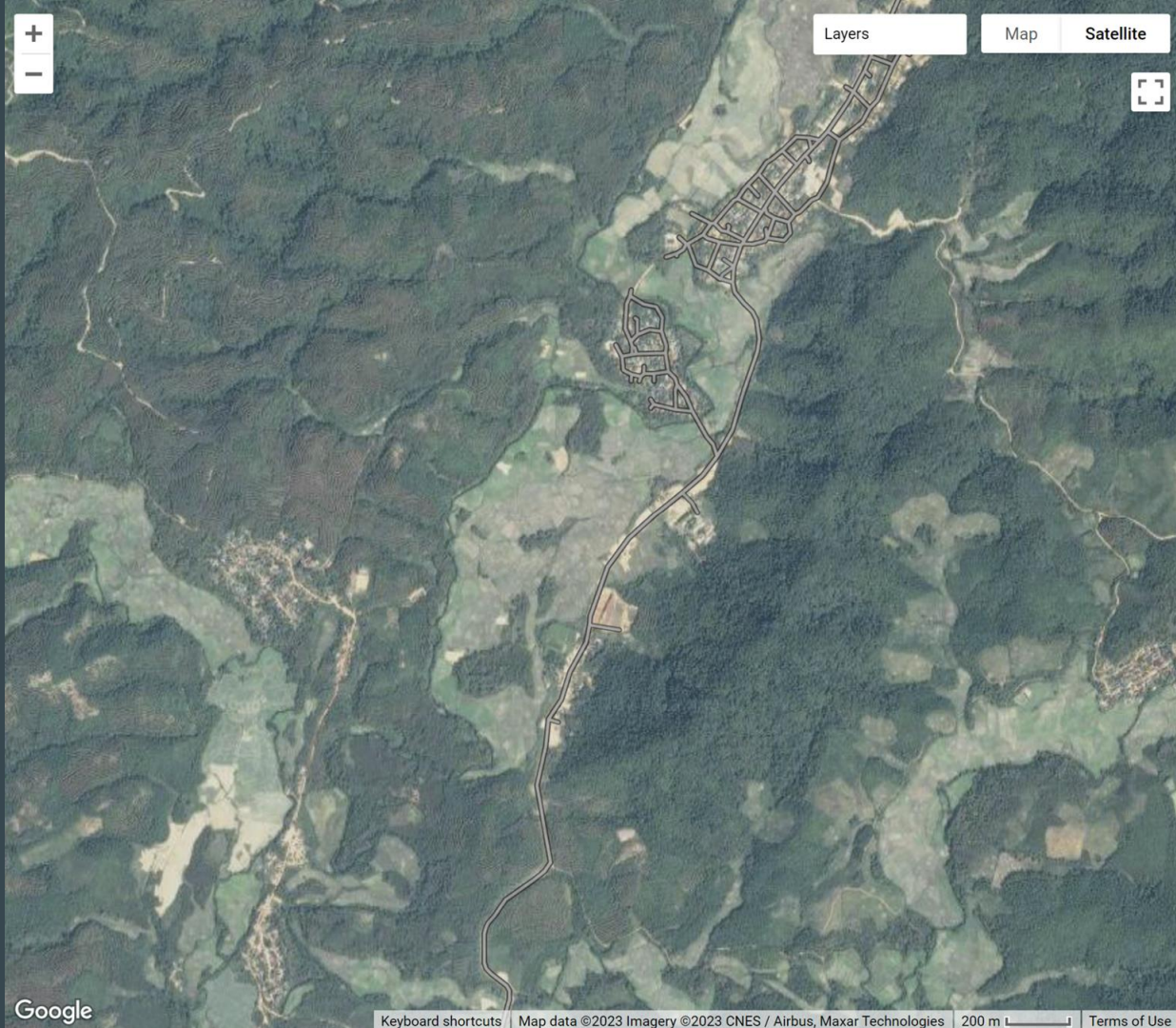


# Magnitude of change





# Google basemap



Google

Keyboard shortcuts

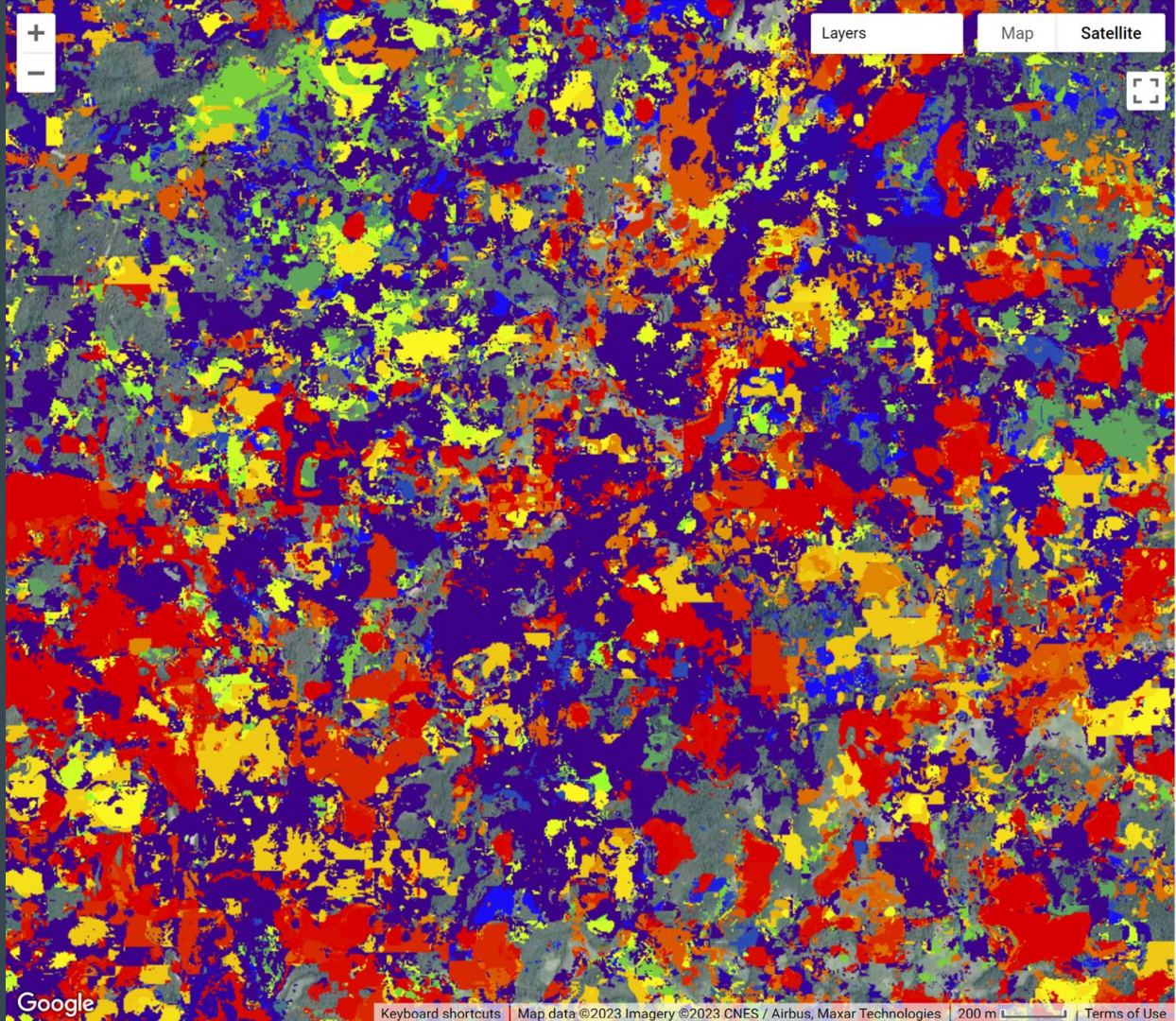
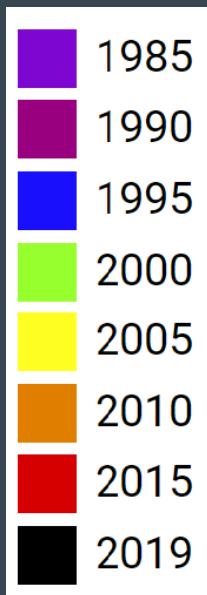
Map data ©2023 Imagery ©2023 CNES / Airbus, Maxar Technologies

200 m

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# Year of change



# Conclusions

- Species richness and diversity were more or less similar in intermediate and later successional phase forests, but significantly different in early phase and plantation forest
- Species composition varied in forest types and all types had type-specific species, plantation type very distant to others
- No significant differences in C, AGB, BA in forest types, but much more variability in forests than in plantation
- From Landtrendr, vegetation trends for plantations generally experienced a decrease from 2005-2007, followed by a steady increase after rubber planting.