Understanding the impact of forest use on forest habitat diversity in Zambia using ILUA I & II biophysical and socioeconomic data

Forestry Department – ILUA II Seminar

Results from the ILUA II programme and their application to forestry development activities in Zambia

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Woods Hole Research Center

Work Objectives

Objective. *Stakeholders make evidence-based decisions in the planning and management of the agricultural sectors and natural resources to support the transition to* ***sustainable*** *agricultural sector productions systems through monitoring, statistics, assessments and analyses – Strategic objective 2*

- The study will employ survey data collected as part of the two phases of the ILUA programme to better understand how forest use is impacting on habitats.
- Using the two ILUA biophysical surveys to quantify the changes in forest habitat and to link these changes to the results seen in the spatial change detection analysis undertaken to support UN REDD activities.
- The study should attempt to explain the changes using information gleaned from the outputs produced by the FLES survey. – Remaining challenge

Analytical Approach

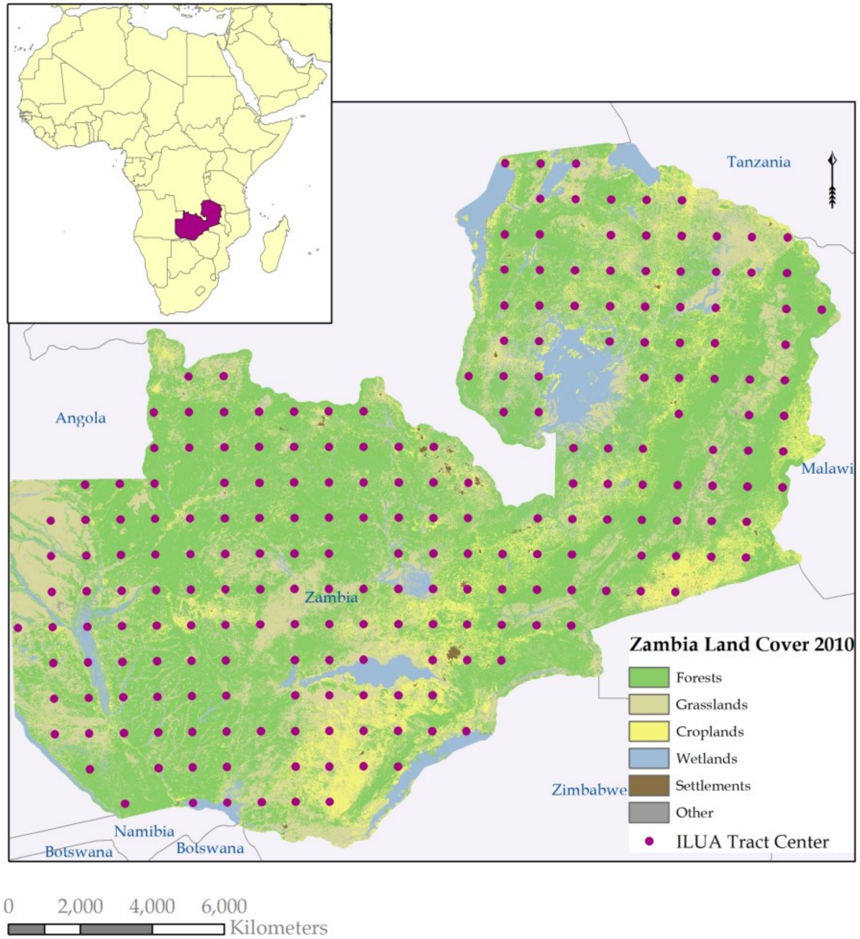
- Assessed the change using different indicators characterizing forest health
- Evaluate sustainability over time

This work focused on productivity (in terms of biomass change) which is a direct indicator of the forest capacity to maintain ecosystem services and be managed sustainably

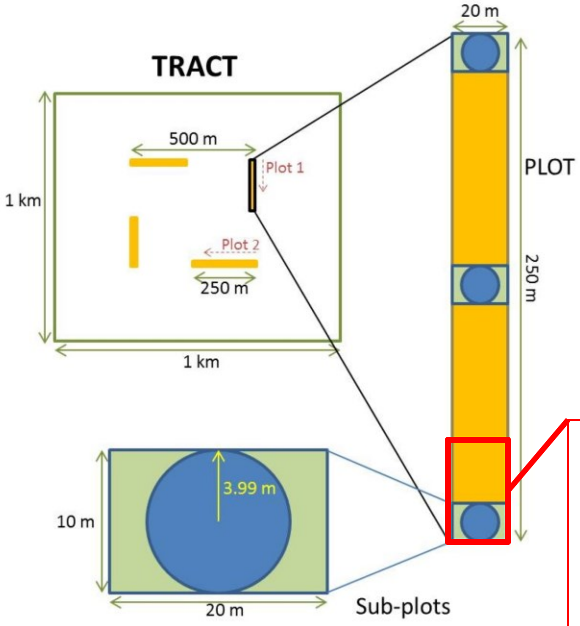
Analytical approach

- Section 1: Summary statistics of the change in forest indicators
- Section 2: Causes of the change
- Section 3: Human impacts on productivity
- Section 4: Biodiversity through species distribution

Methodological approach



Sampling Design



Compare the area of overlap between ILUA I & ILUA II

Section 1

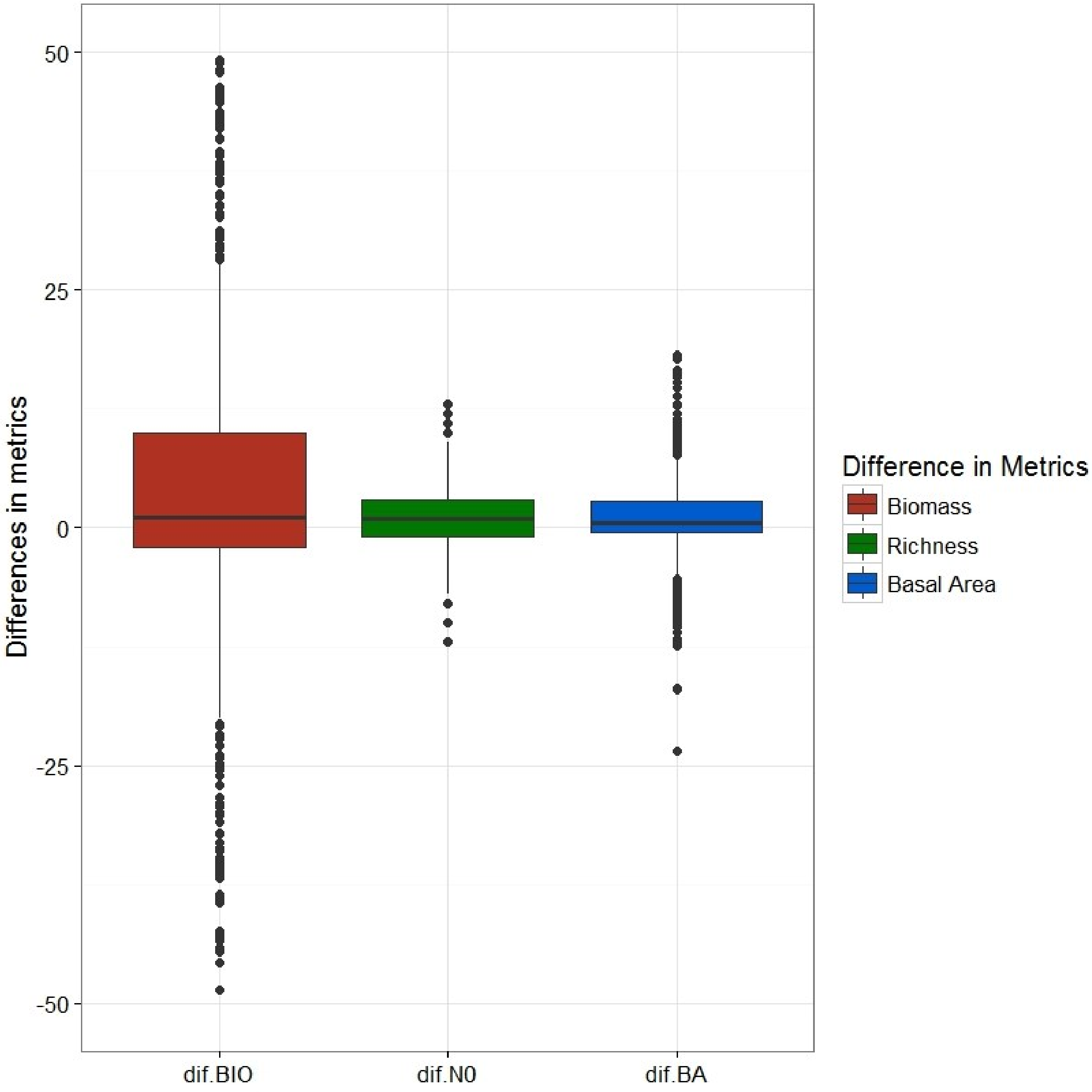
Summary statistics:

Differences in Biomass

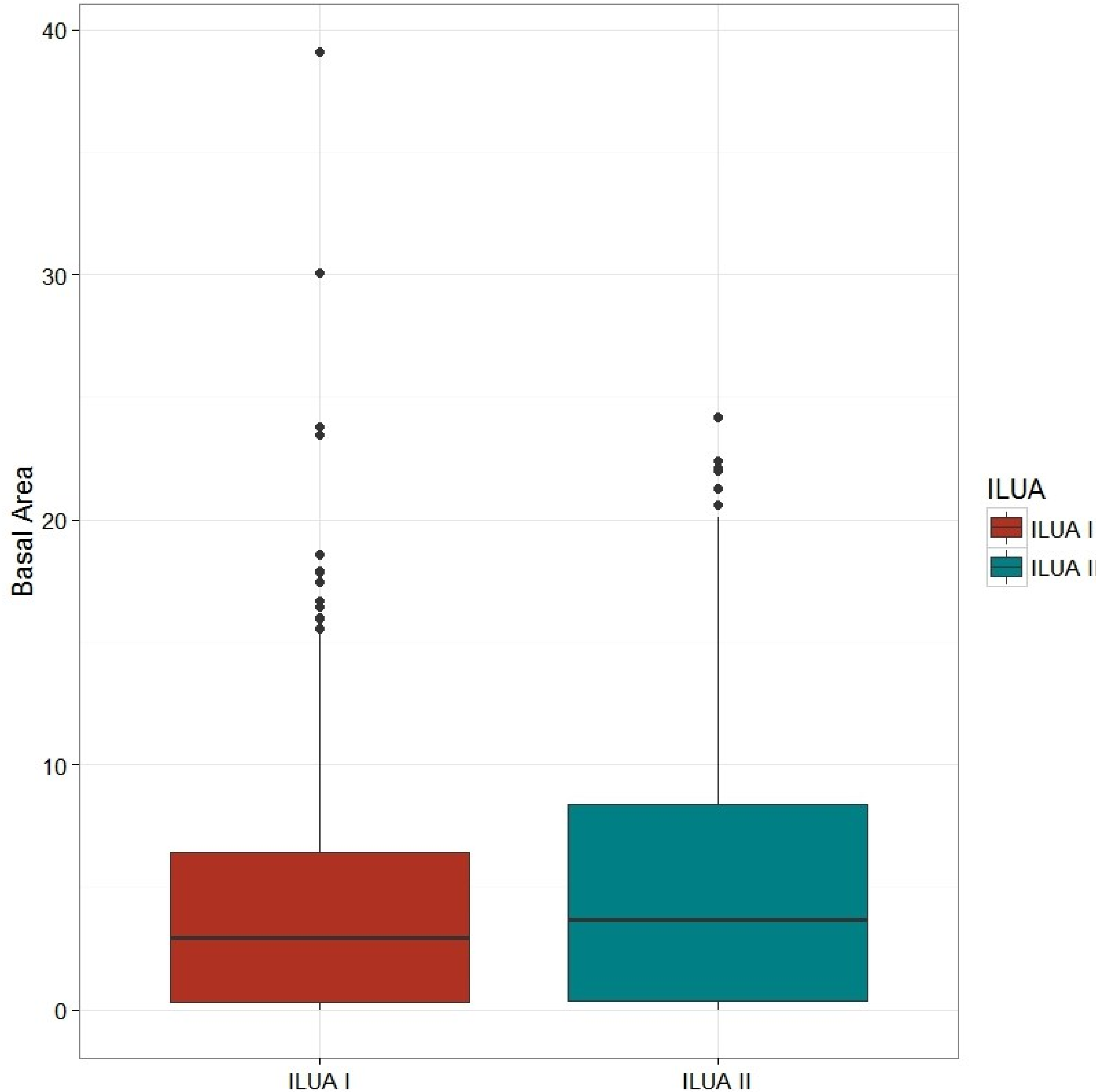
Richness

Basal Area between

ILUA I and II

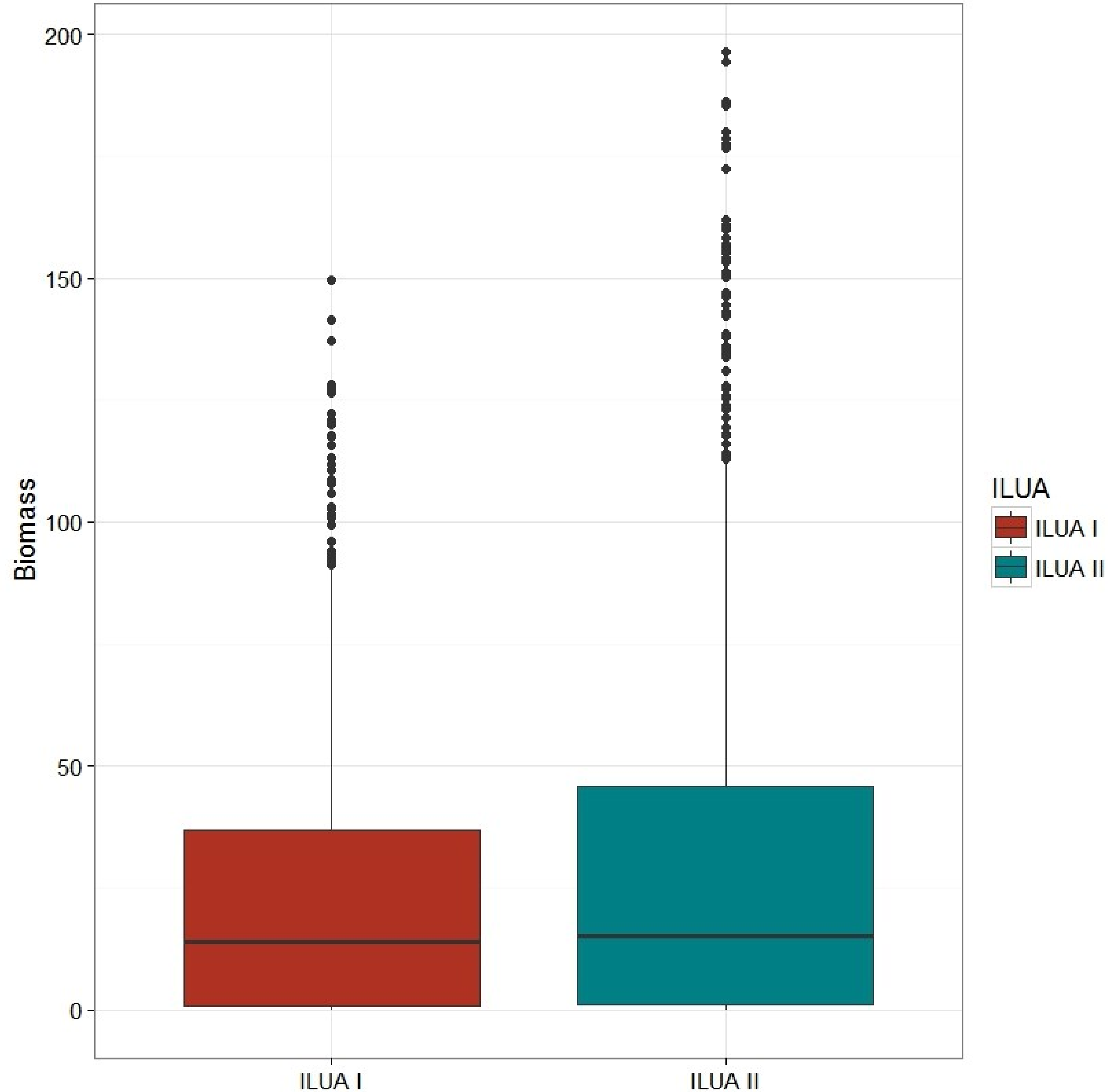


Summary statistics: Basal Area



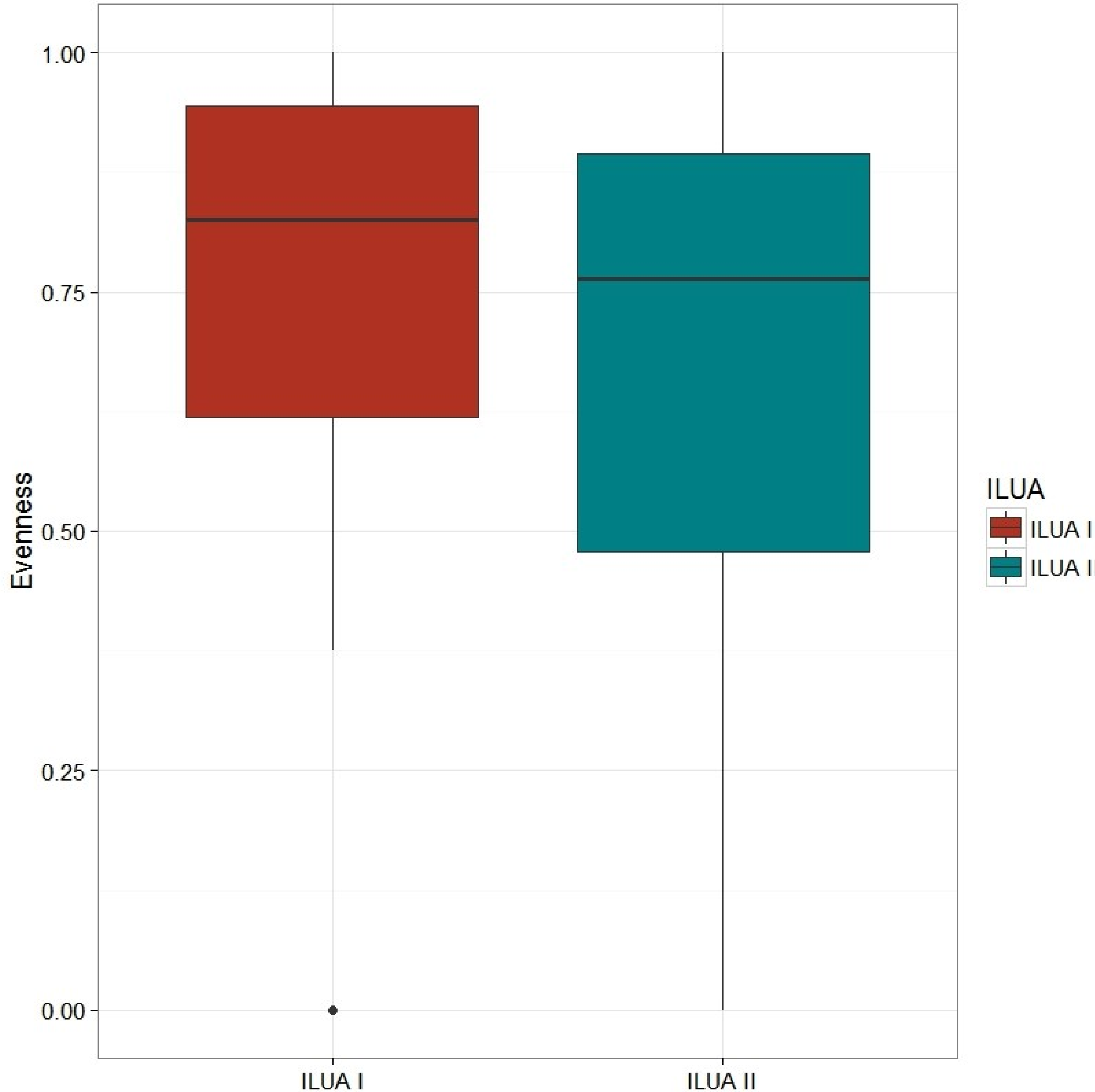
t = -3.6373, df = 1634.1, p-value = 0.000284

Summary statistics: Biomass



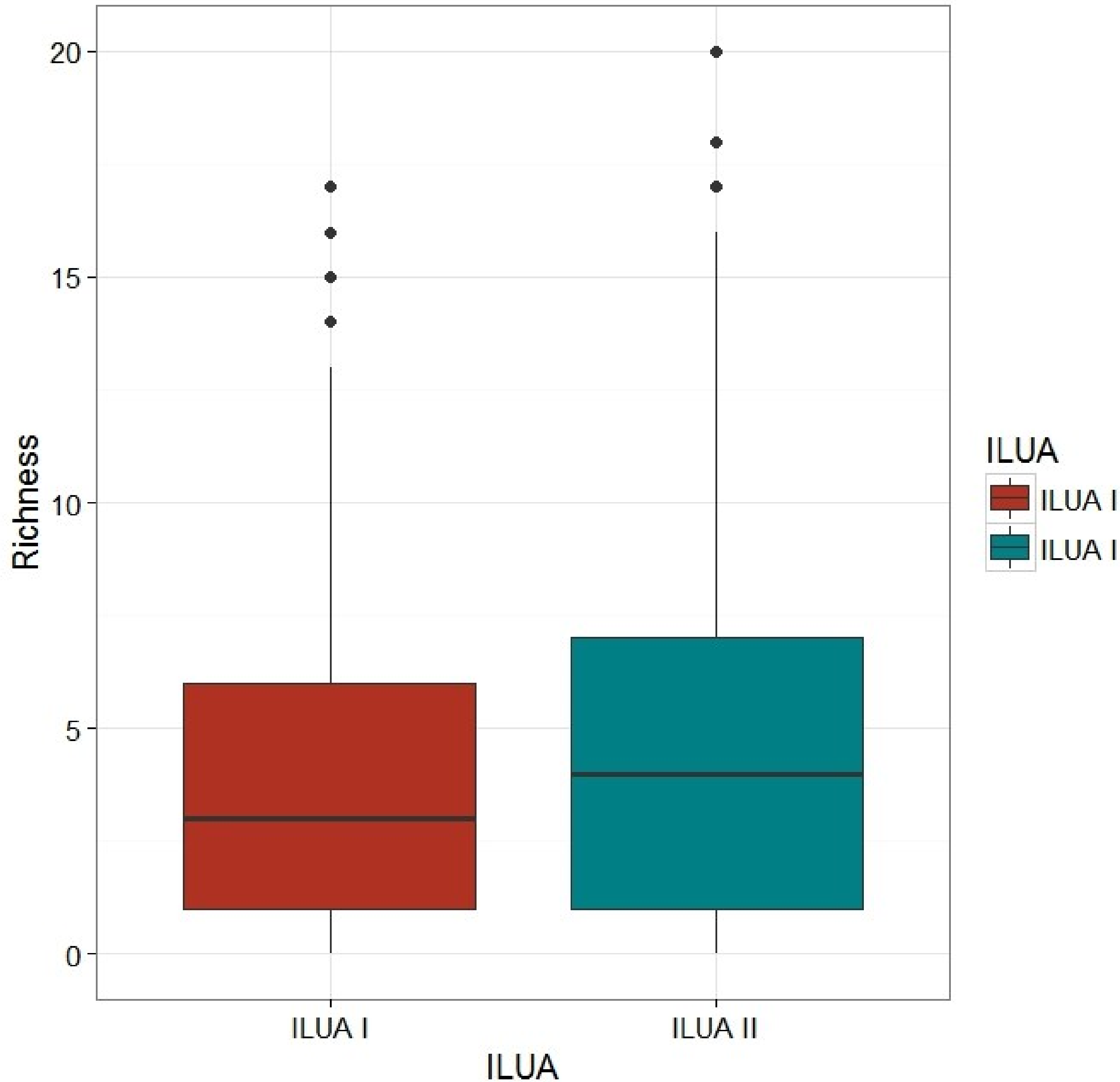
t = -4.0806, df = 1552.9, p-value = 4.72e-05

Summary statistics: Species Evenness



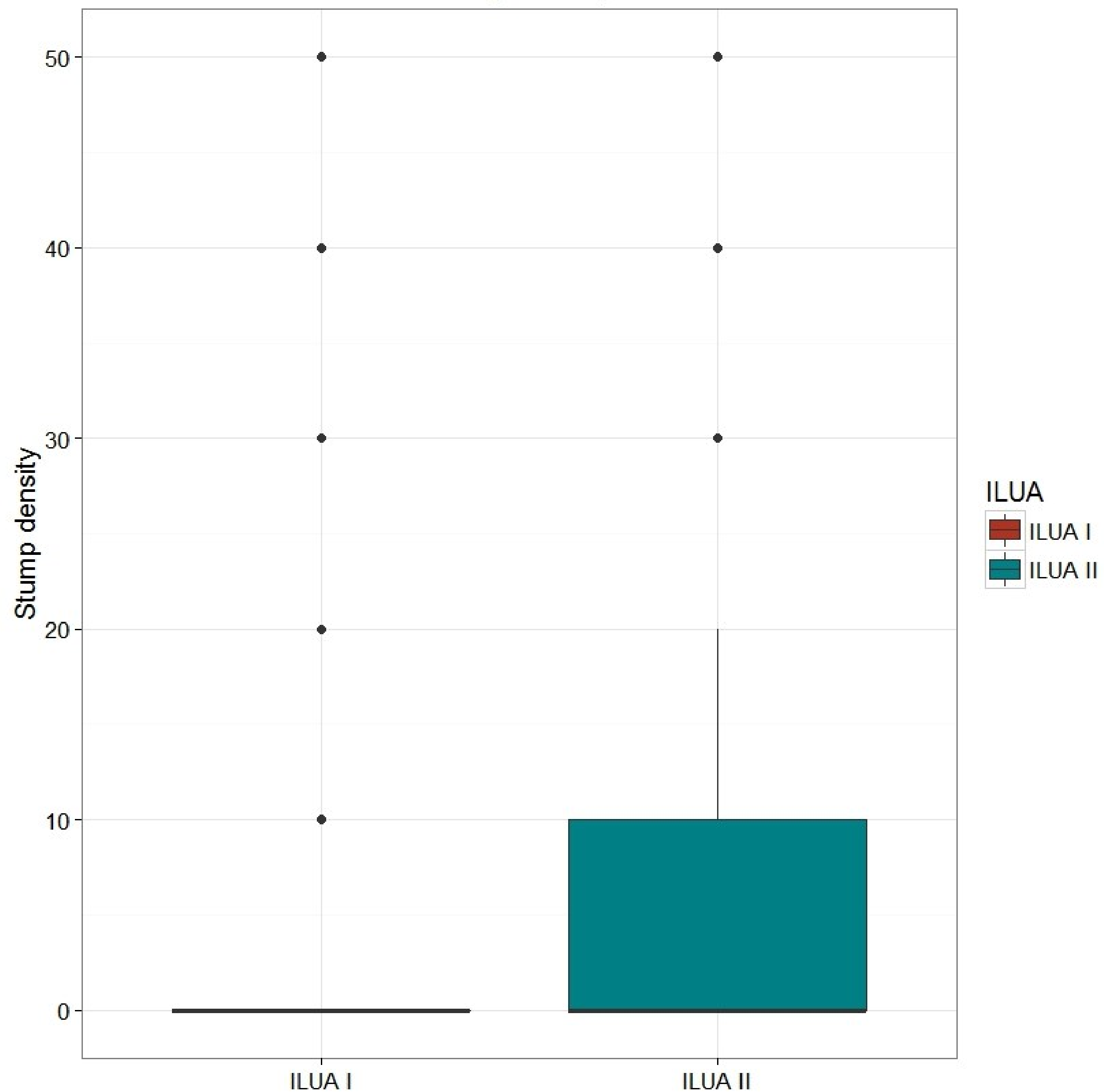
t = 2.7228, df = 1654.6, p-value = 0.00654

Summary statistics: Species Richness



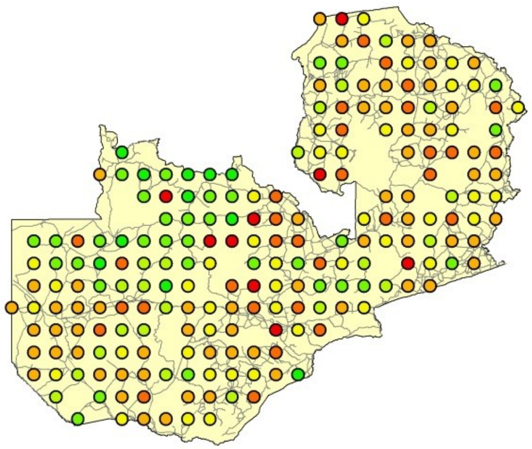
t = -5.6918, df = 1551.2, p-value = 1.5e-08

Summary statistics: Stump density

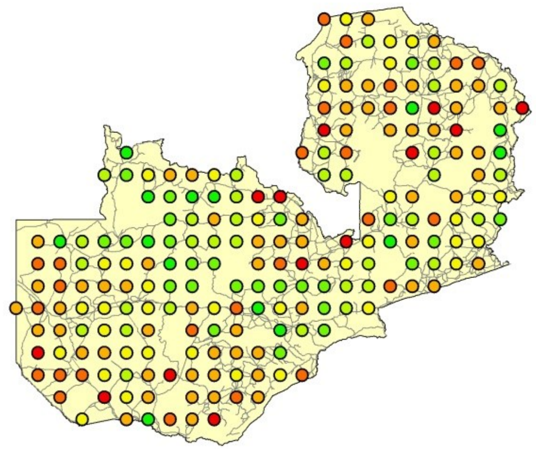


t = -3.3071, df = 1632.7, p-value = 0.000963

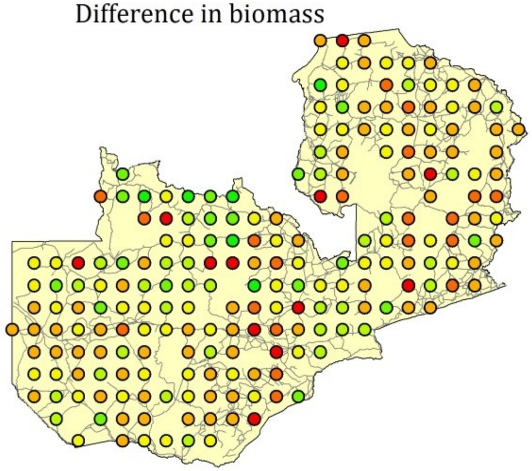
Gain or loss over time?



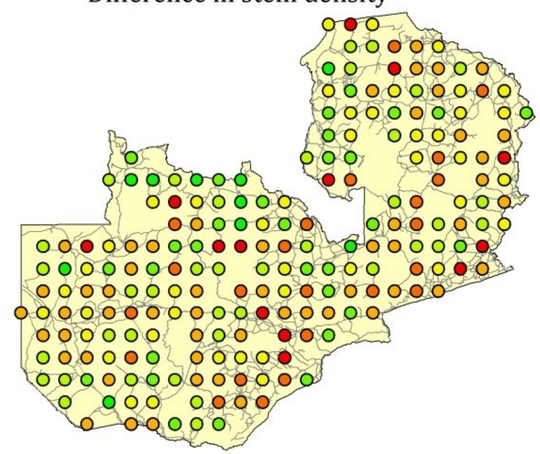
Difference in biomass



Difference in stem density



Difference in basal area



Difference in species richness

Overall gain

	Δ Biomass (Mg/ha)	Δ Species richness	Δ Stem density	Δ Basal Area	Δ Stump density	Δ Evenness
	Cluster level (N=211)					
Mean difference	8.48	1.94	-89.66	0.99	2.37	-0.08
Nb with Gain	118	122	56	128	87	72
Nb with Loss	84	65	144	74	48	127
Nb with no change	9	24	24	9	76	12
25th percentile	-3.35	-1.00	-150.00	-0.49	0.00	-0.24
median	1.88	1.00	-50.00	0.63	0.00	-0.05
75th percentile	15.04	6.00	5.00	2.64	5.00	0.06
	Plot level (N=829)					
Mean difference	7.42	1.03	-147.37	0.83	2.34	-0.06
Nb with Gain	475	428	146	470	192	255
Nb with Loss	254	221	565	260	84	425
Nb with no change	100	180	118	99	553	149
25th percentile	-2.36	-1.00	-220.00	-0.46	0.00	-0.25
median	1.96	1.00	-60.00	0.50	0.00	-0.02
75th percentile	14.90	3.00	0.00	2.69	0.00	0.07

On average, we find that forests are sequestering carbon

Section 2: Causes of the change

Gain or loss of biomass and other indicators between ILUA I & ILUA II- Why is it happening?

Human impacts → loss

Diversity → gain

Statistical approach in the family of structural equation modelling: **Path analysis**

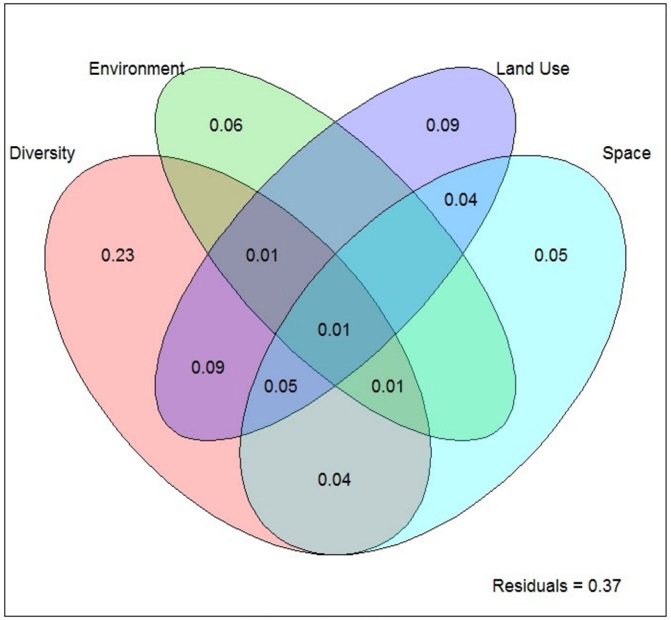
- Allowing to model and understand direct and indirect causes

ILUA I: human and natural controls in stocks

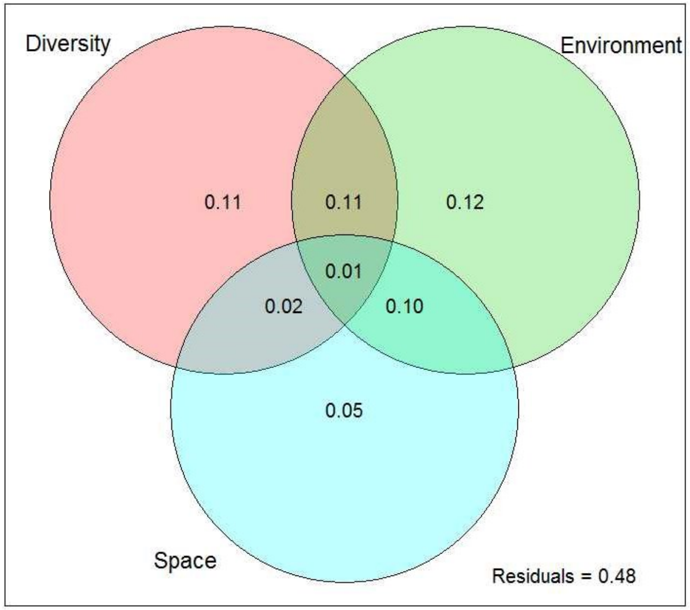
Human

Natural

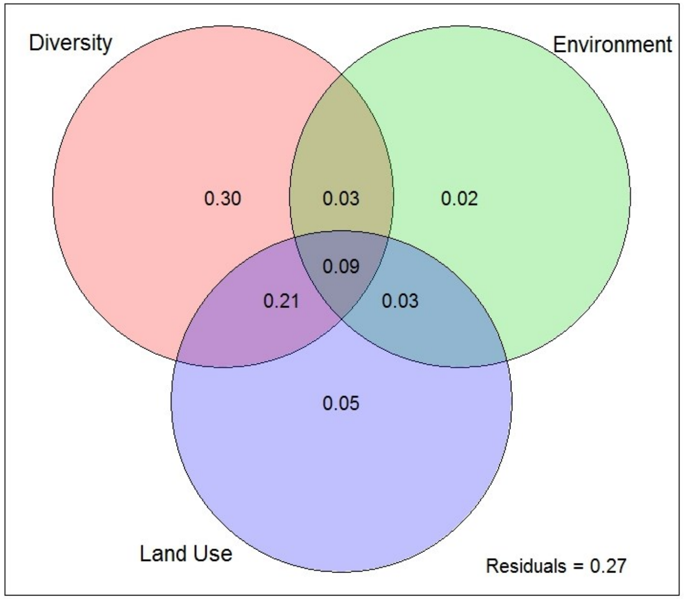
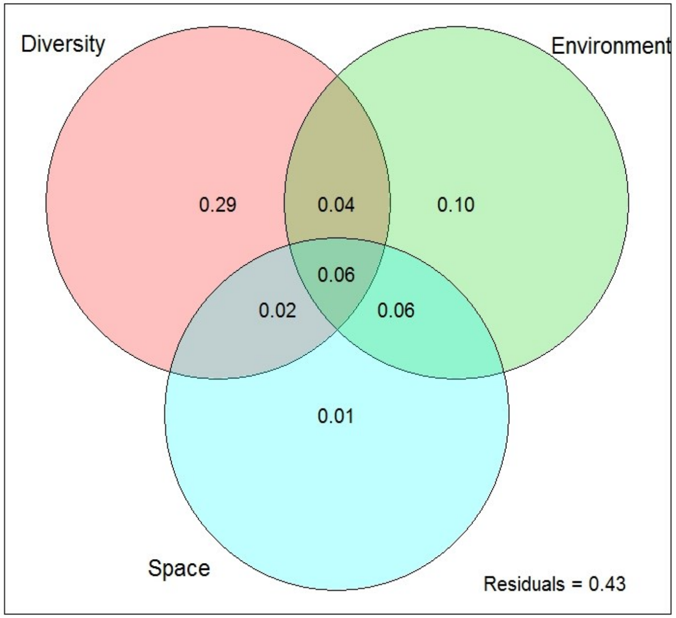
TRACT LEVEL:



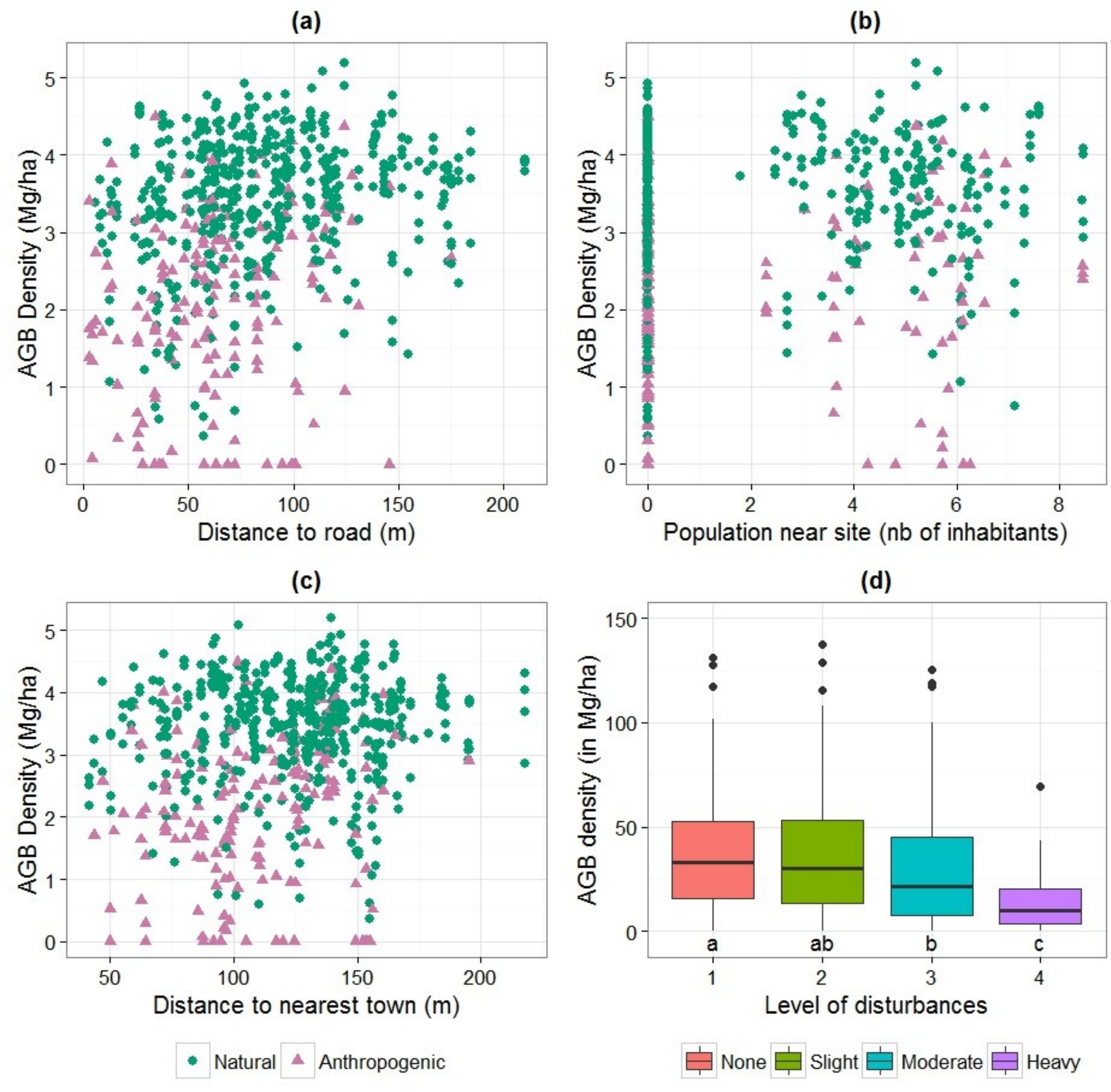
Values <0 not shown



ILUA I: human and natural controls in stocks

	Human	Natural
PLOT LEVEL:		

ILUA I: Human impacts



Findings ILUA I: Explaining variation in biomass density

- At natural sites, diversity and environmental variables are important
- At human sites, diversity alone and the shared fraction of land use and diversity are key
- Carbon is more distributed in the landscape

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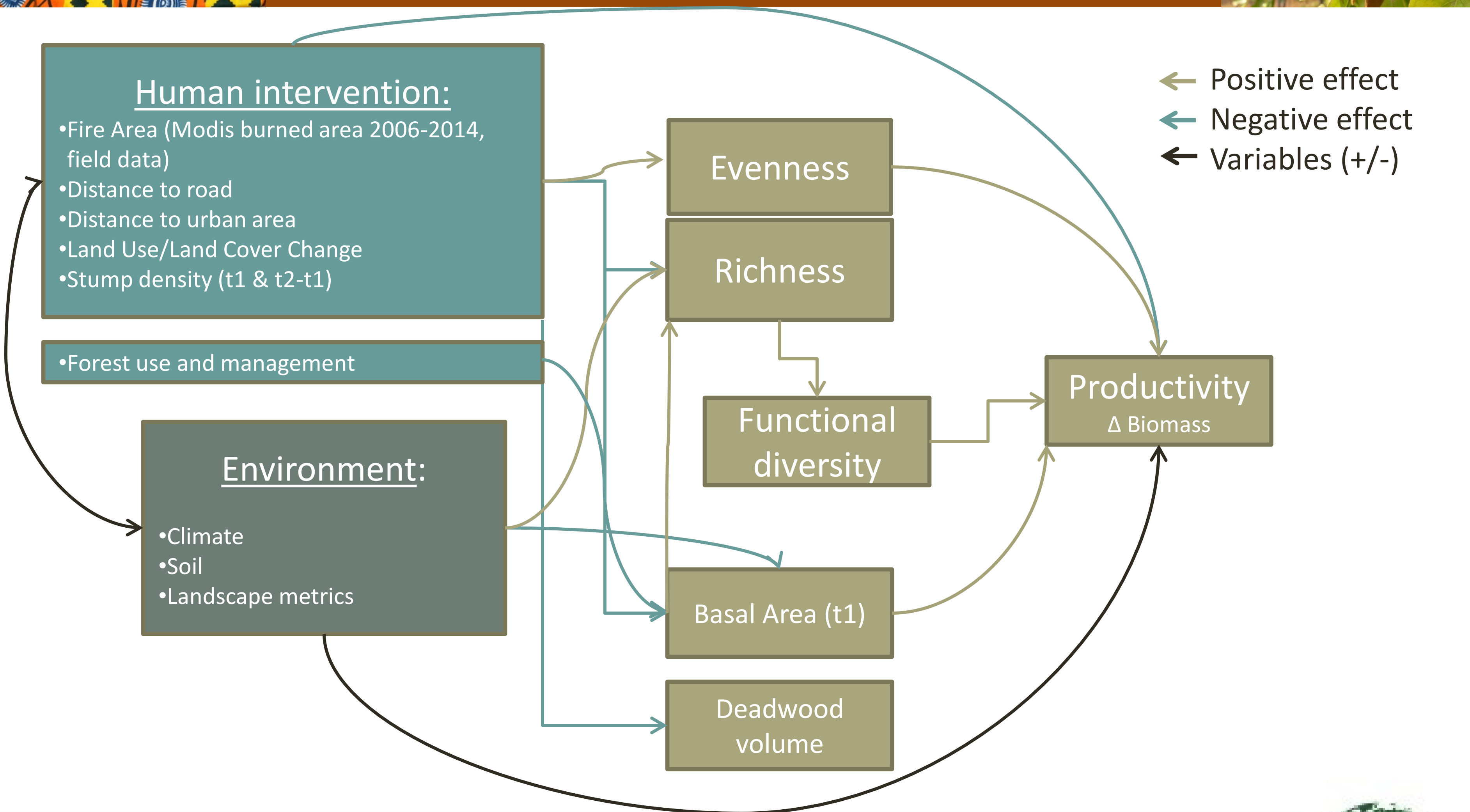
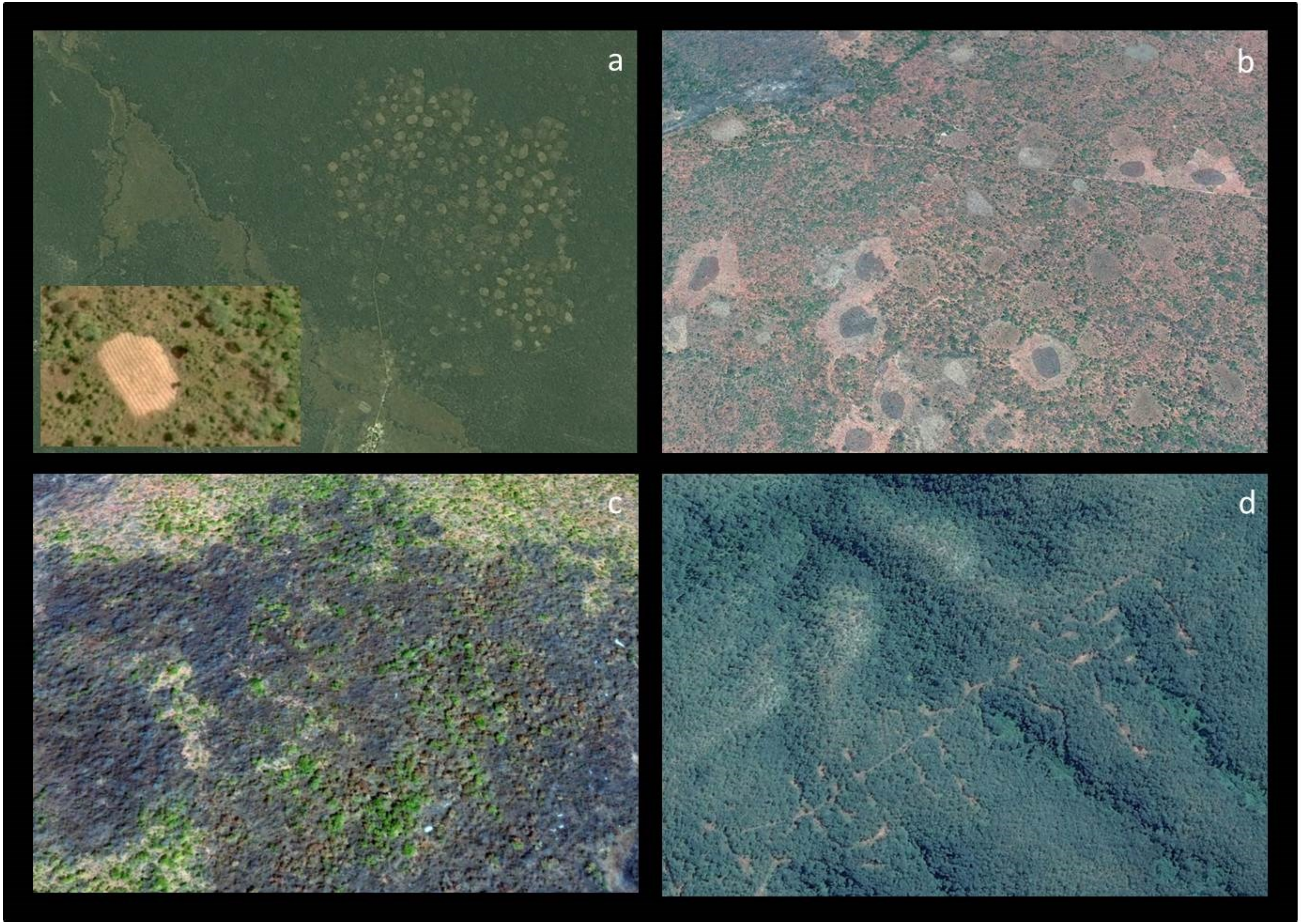
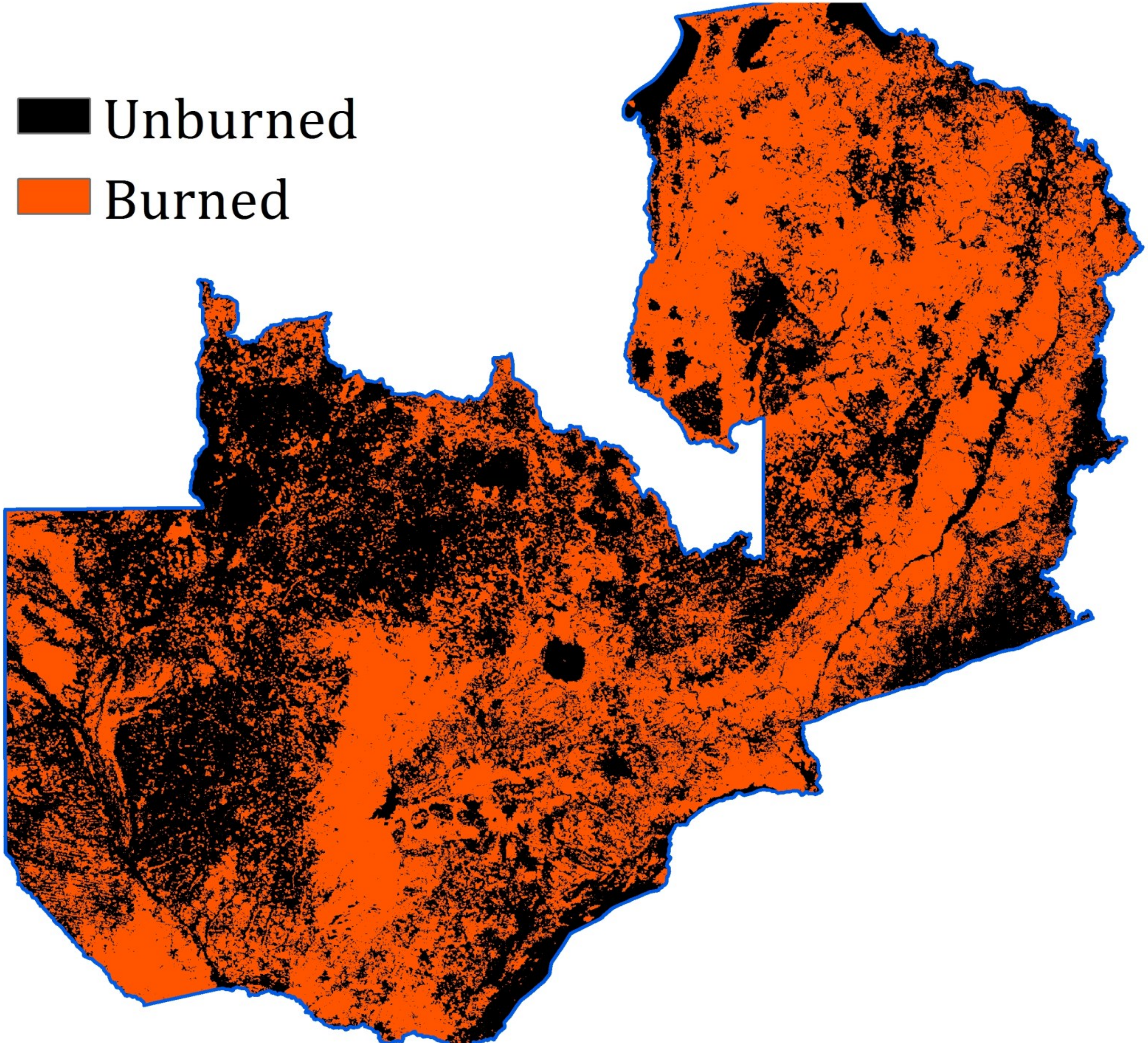
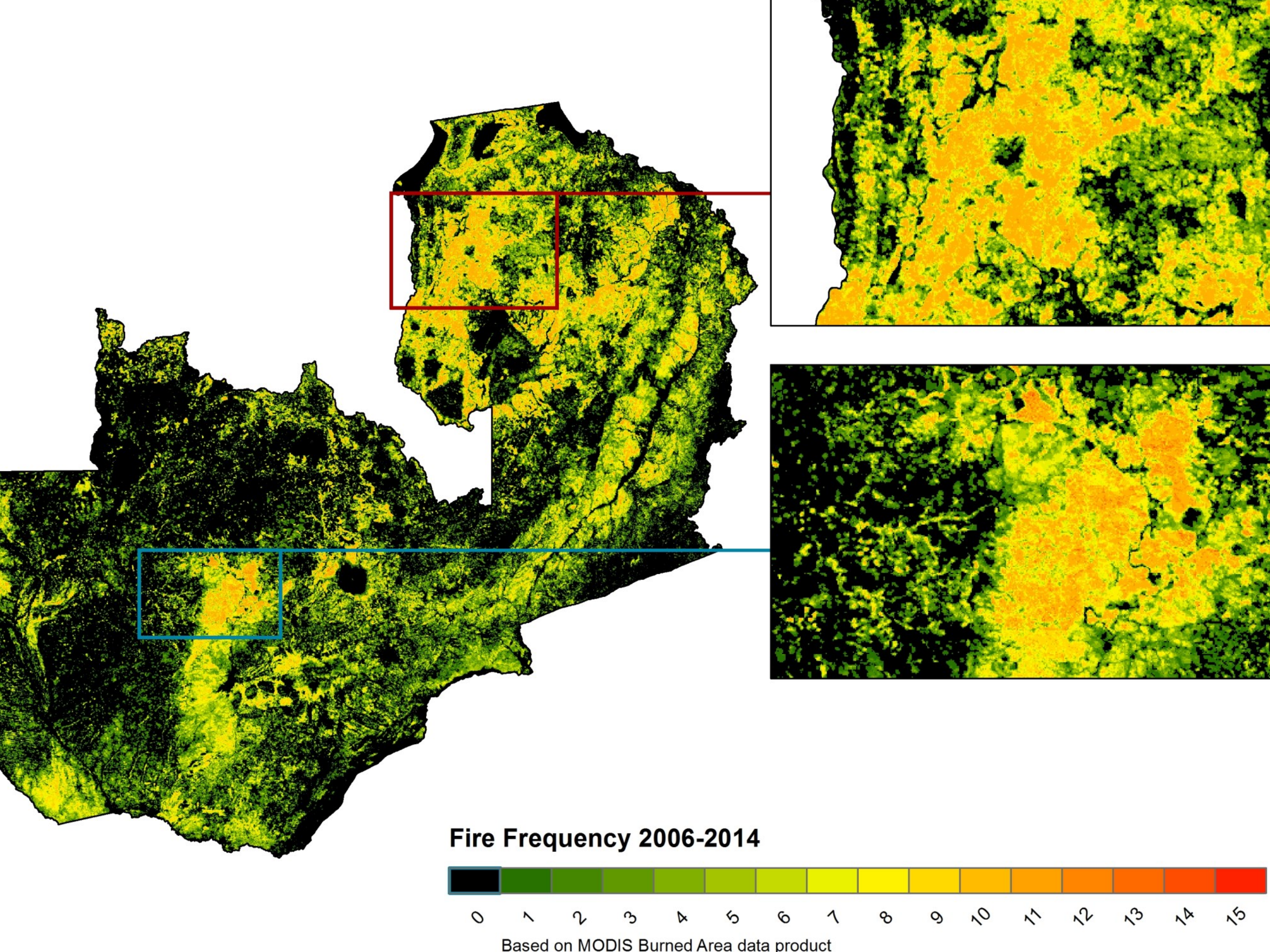
Conceptual framework

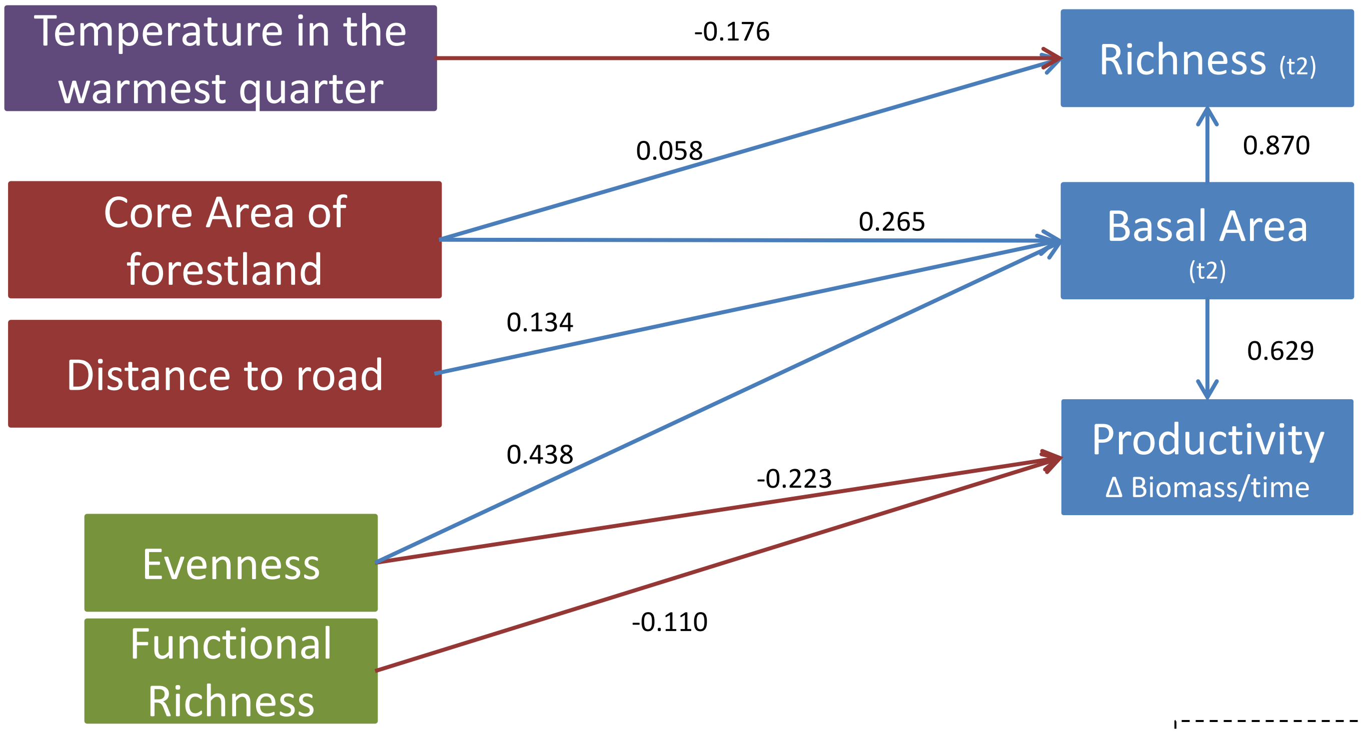



a
b
c
d


Unburned
Burned


Fire Frequency 2006-2014
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Based on MODIS Burned Area data product

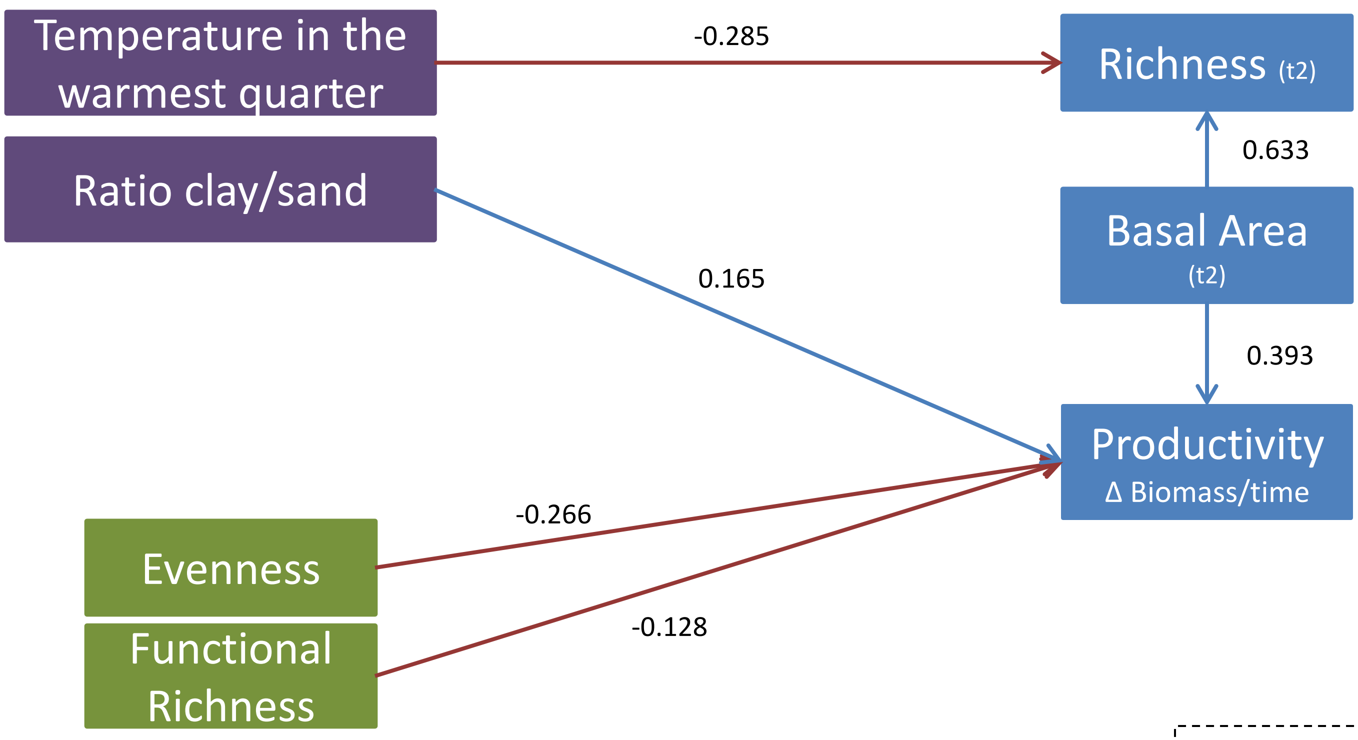
All plots



R-Square:

	Estimate
Richness	0.803
Productivity	0.342
Basal area	0.280

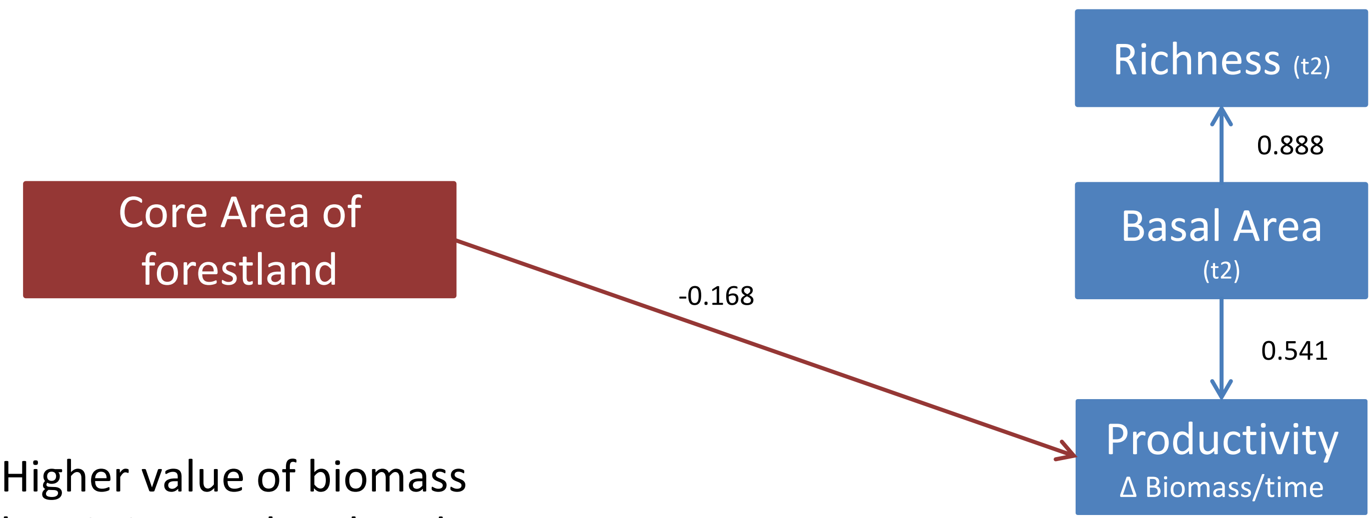
Plots- *Forest remaining forest*



R-Square:

	Estimate
Richness	0.475
Productivity	0.277

Plots- *Forest to non-forest*

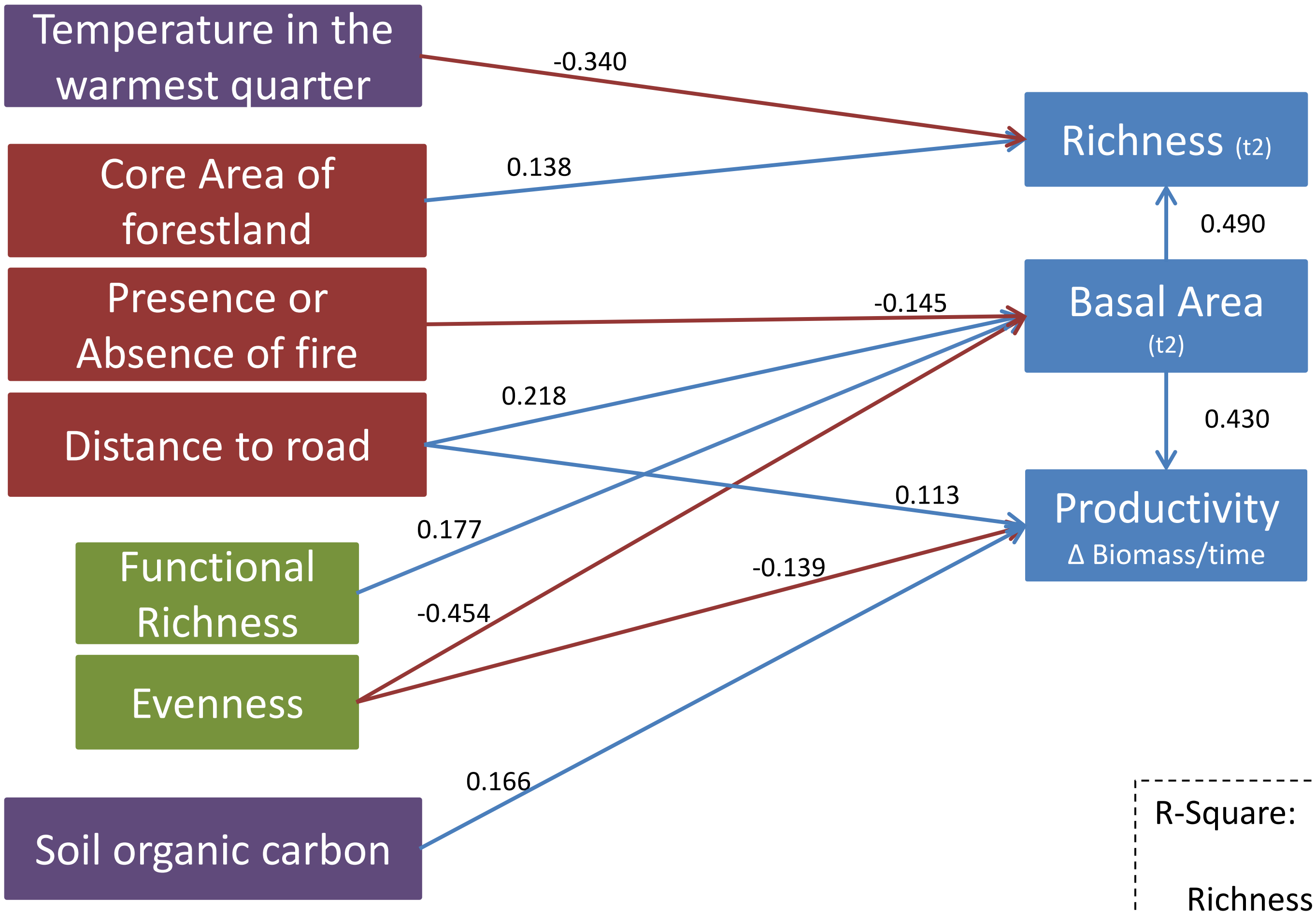


Higher value of biomass loss is inversely related to core area of forestland

R-Square:

	Estimate
Richness	0.788
Productivity	0.313

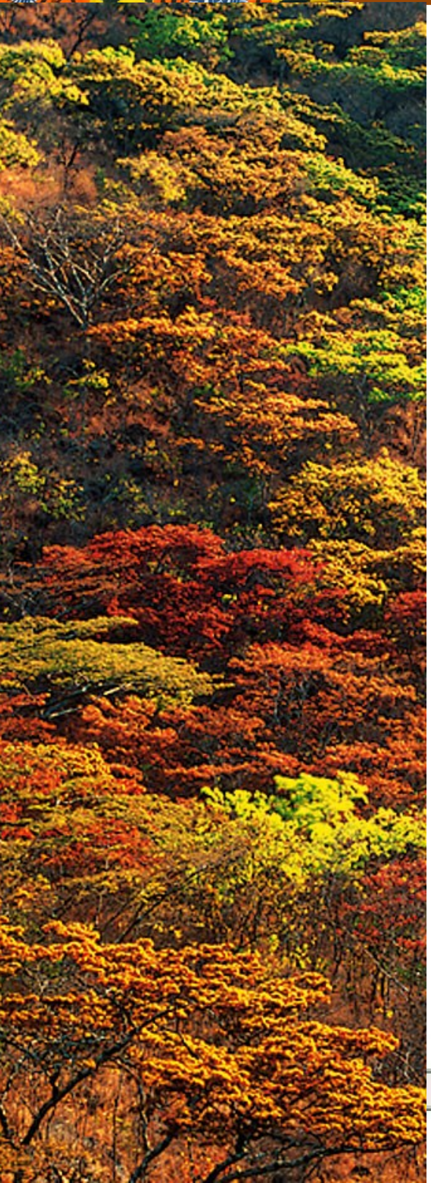
Plots- *with biomass gain*



R-Square:

	Estimate
Richness	0.381
Productivity	0.331
Basal area	0.341

Section 2: causes of the change

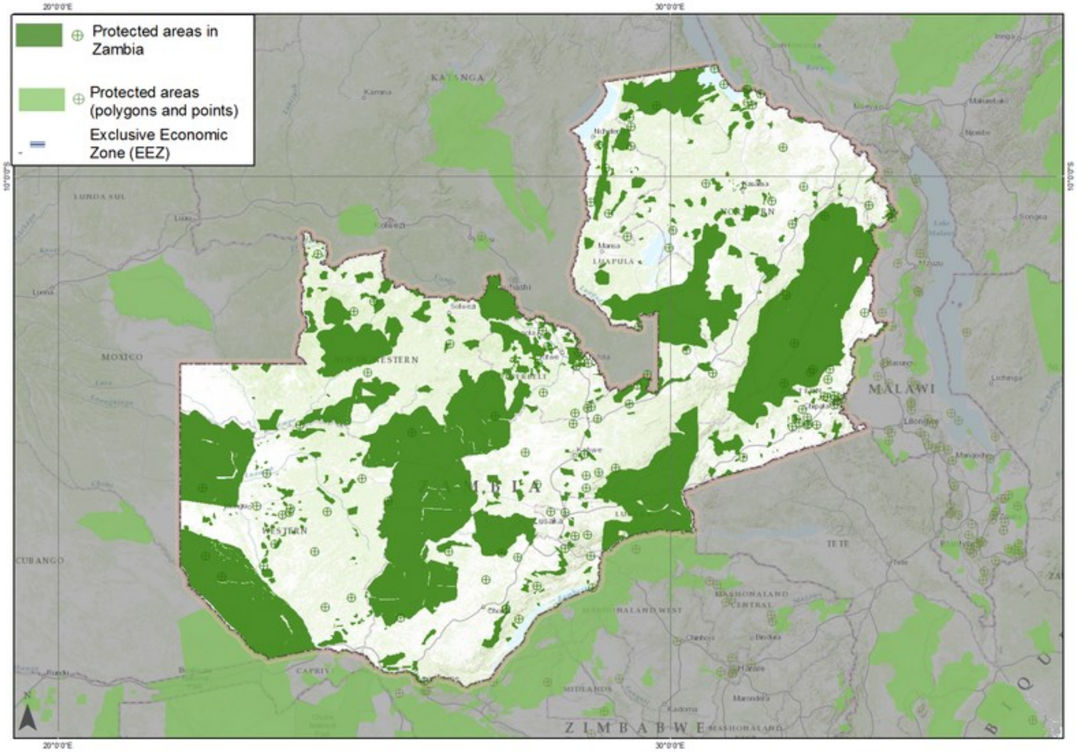


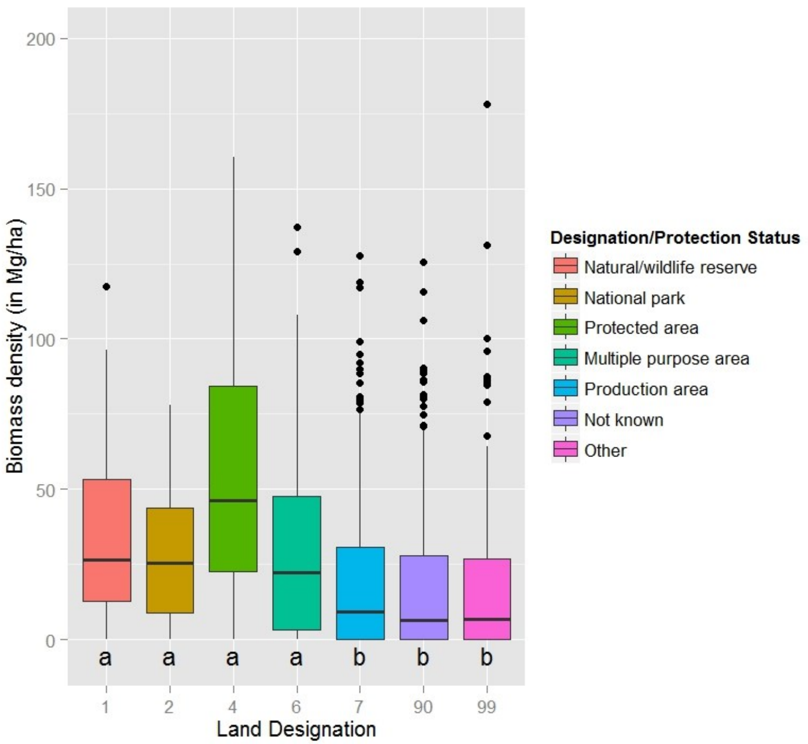
- Different trajectories of change are caused by different factors
- Functional richness and dominance are important in sites with low impacts
- Proxy of human activities (fragmentation, distance to road)
- Environmental variables also constrain productivity and richness

Section 3:
Impacts of human activities

Analyze the impacts of different human activities on productivity, that is on the difference in biomass over time.

ILUA I : Role of land designation

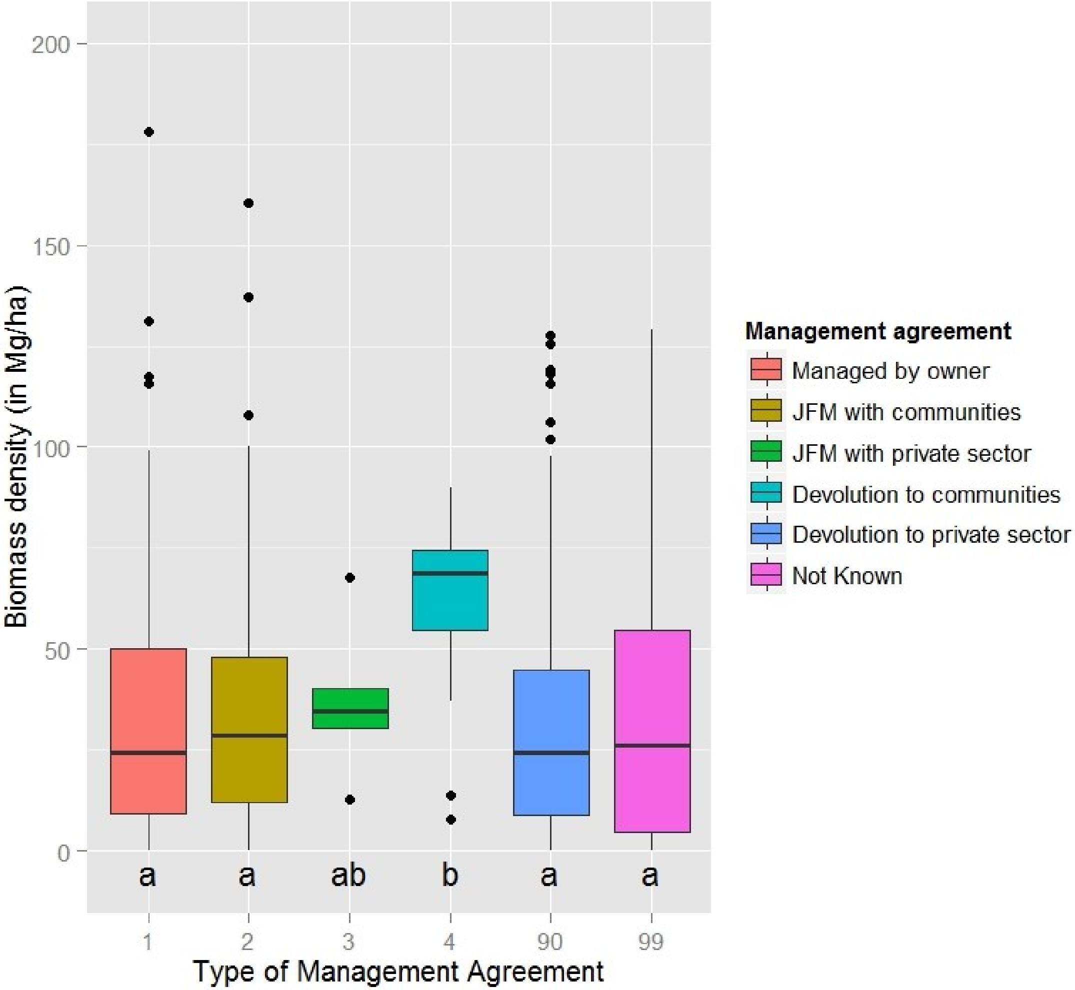




Significantly higher biomass in land under conservation status, including natural reserve, national park, multiple purpose and other protected areas

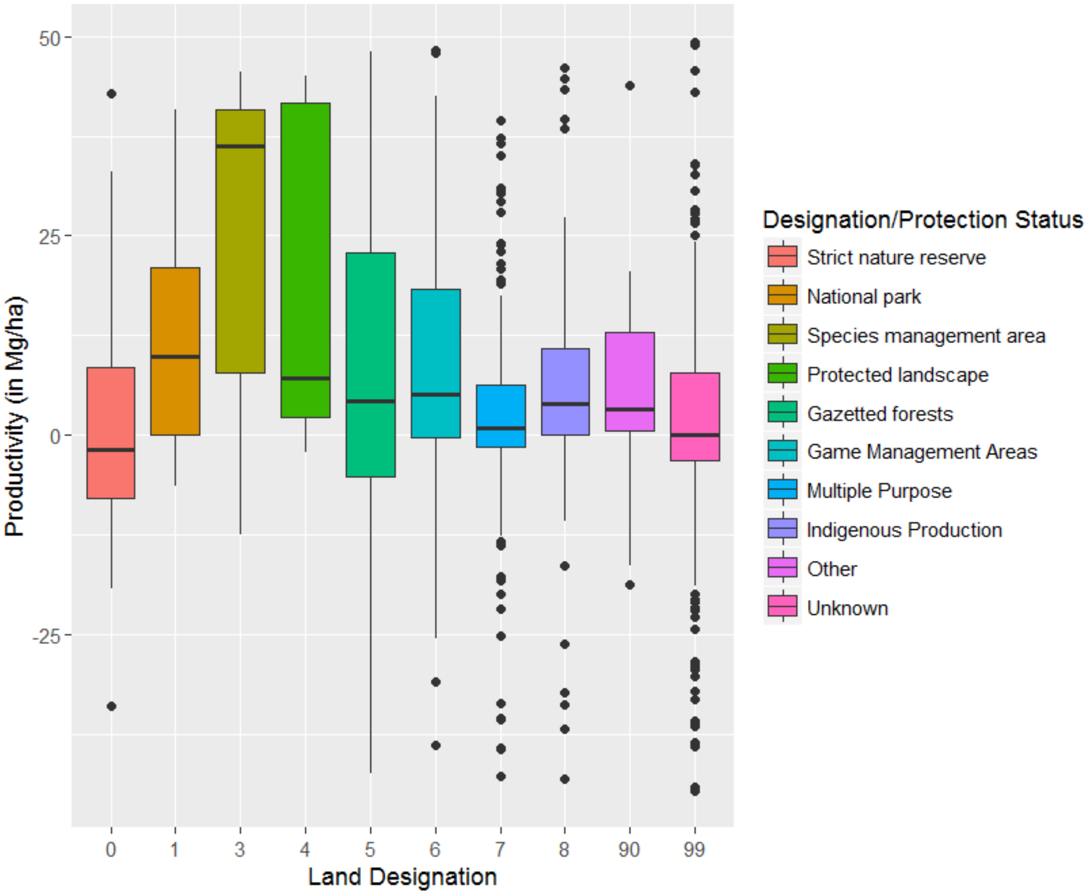
ILUA I: *Type of management agreement*

Higher biomass density when forest management is **given to communities** or when the government **managed forest with other stakeholders**



Productivity between land designation

Species management areas has higher productivity with strict management, multiple purpose and unknown designation. Unknown designation is also significantly different national parks, protected landscape and game management areas.



Fire type on productivity

For fire type, we identified a significant difference between the types of fire using ANOVA with permutational test but not with probabilistic test. Post hoc test doesn't confirm the differences.

For ILUA II:

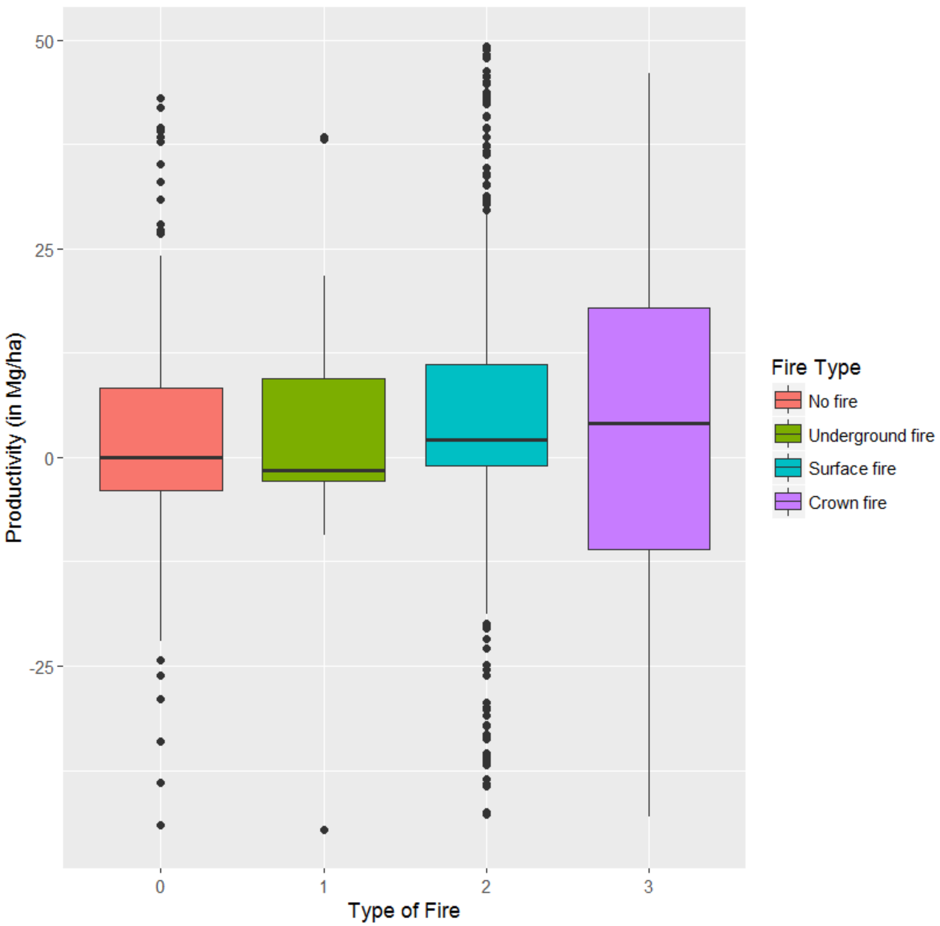
173 -no fire

19 - underground fire

508 - surface fire

4 - crown fire

Similar for ILUA I

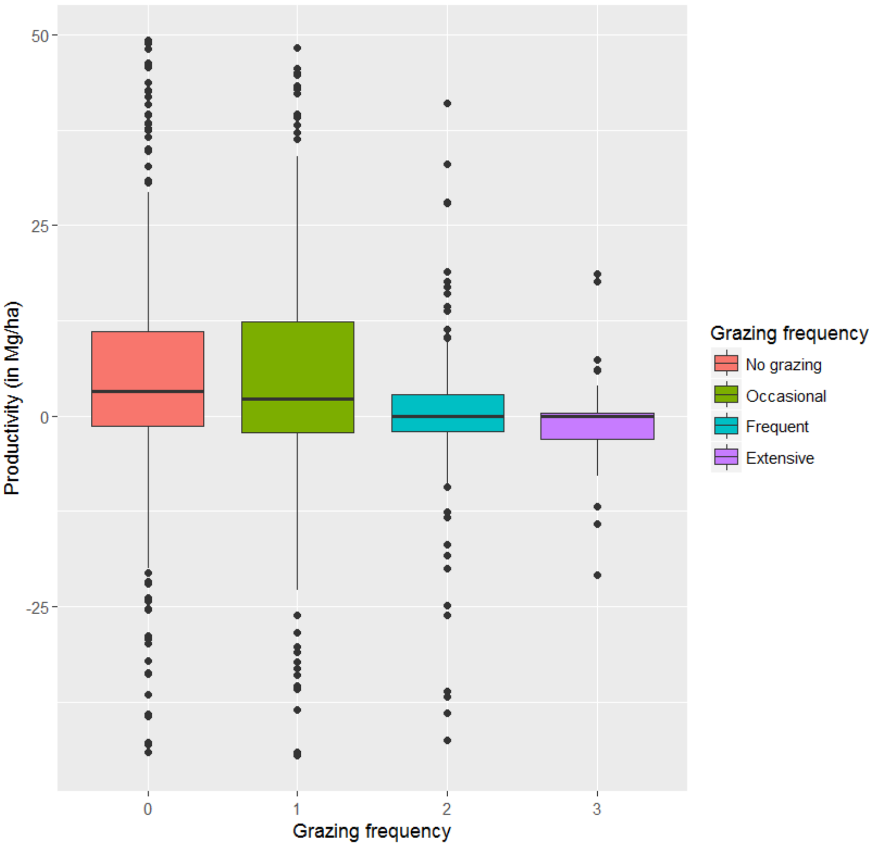


Grazing on productivity

Grazing can significantly affect negatively productivity:

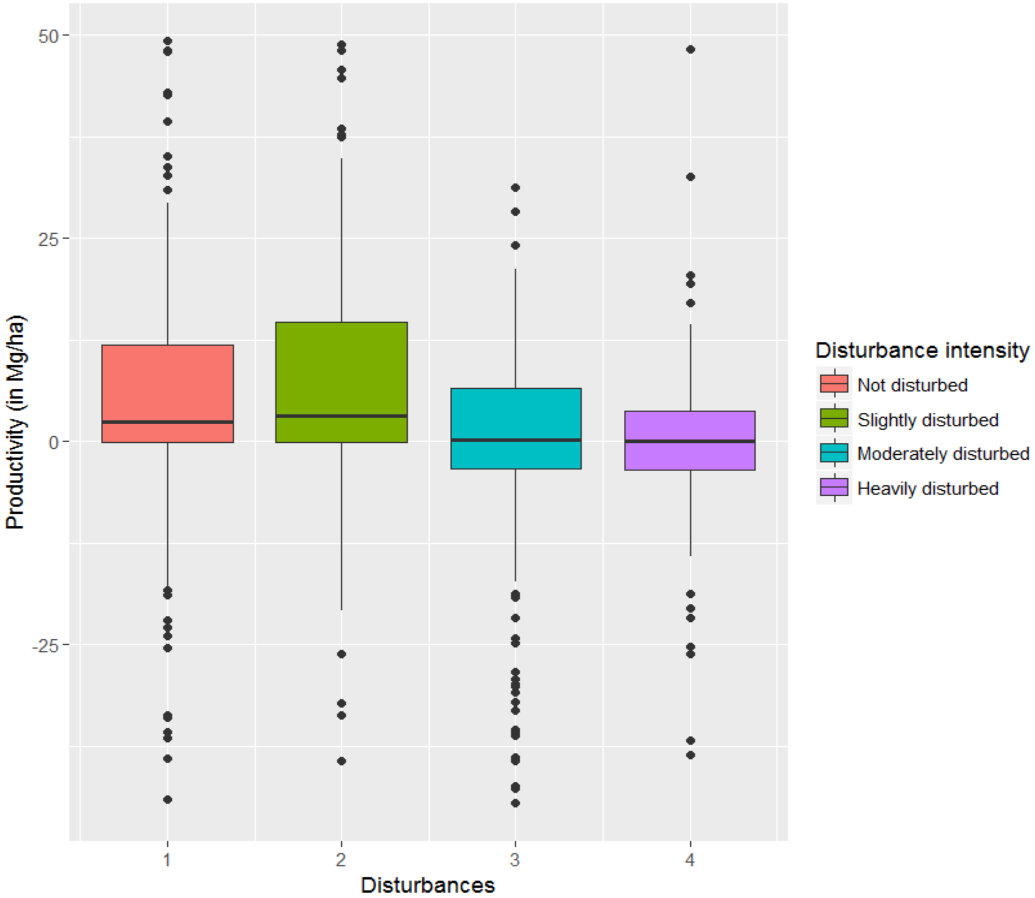
Statistical difference between the sites without grazing with those with frequent grazing.

No visible grazing (n=385)
Only 31 plots experienced extensive grazing.



Disturbance intensity on productivity

Undisturbed and slightly disturbed sites show significantly higher productivity than moderately and highly disturbed sites.

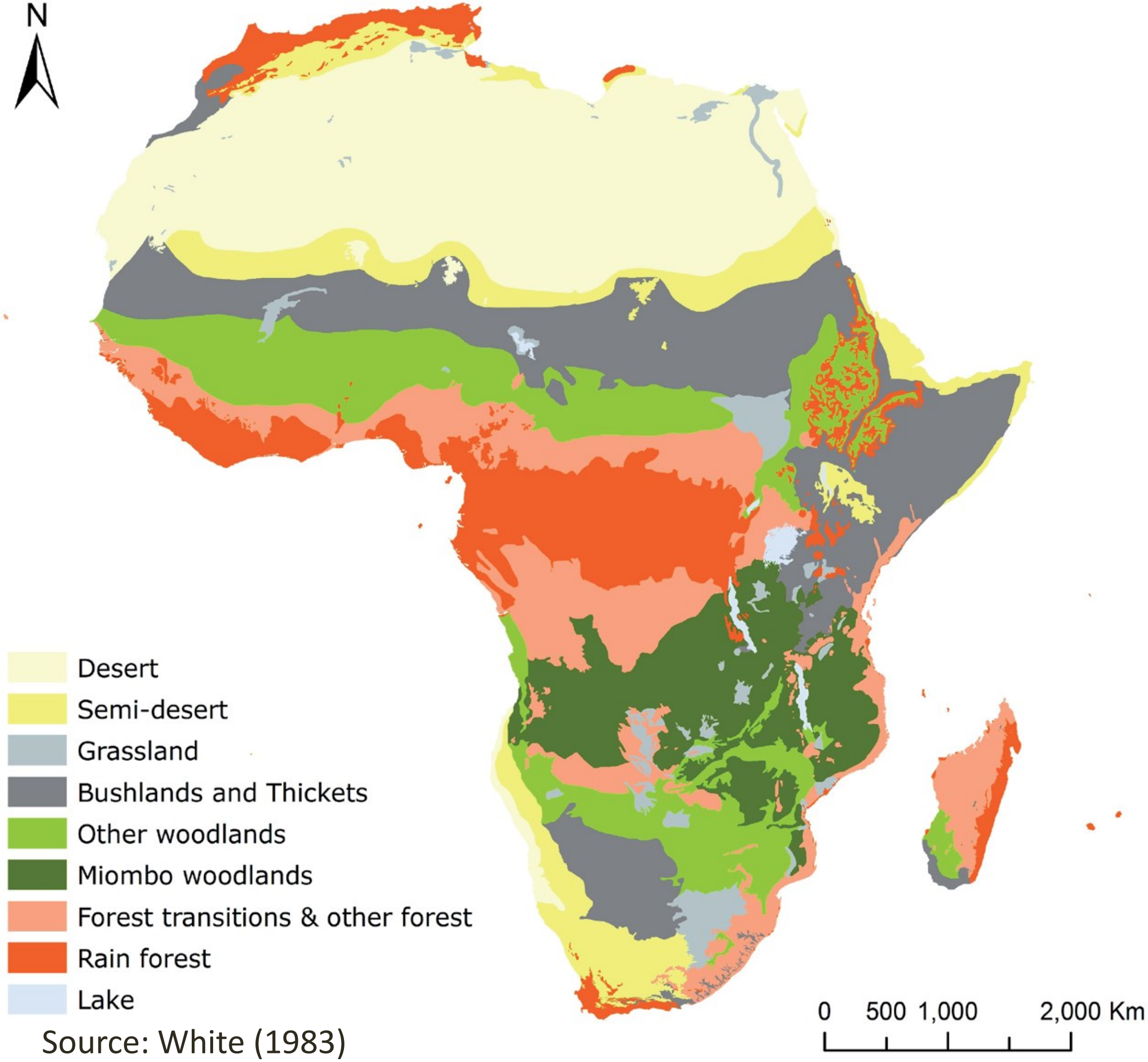


No significant effect on productivity

1. Timber exploitation:
    1. No timber exploitation (n=490)
    2. Single tree selective cutting (n=56)
2. Land ownership:
    1. Customary land category (n=484),
    2. Public land (n=96)
    3. Private land (n=62)
3. Fire occurrence, environmental problems, environmental problems intensity, and livestock management

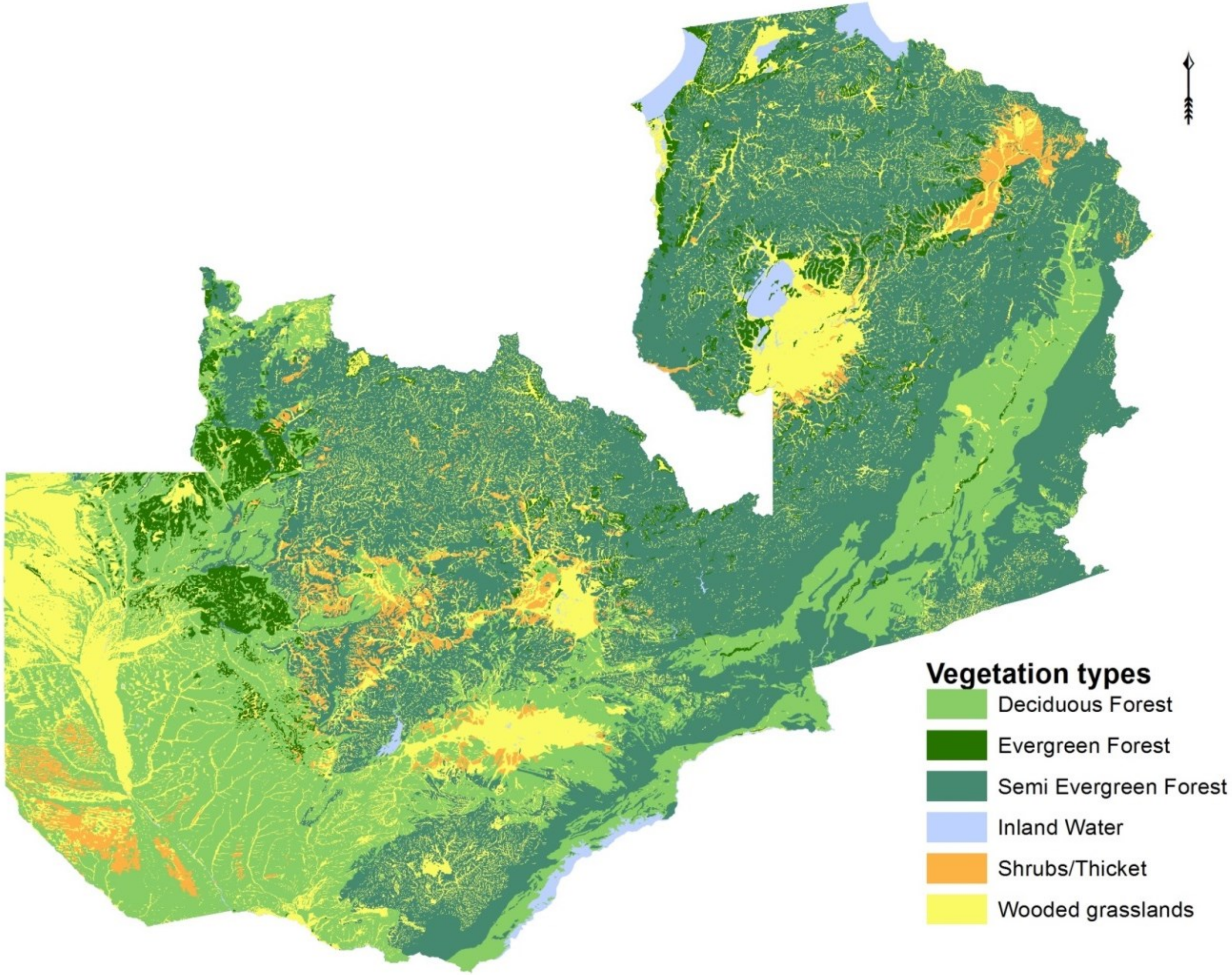
Section 4: species distribution

Miombo woodlands covers between 2.4-3.6 million km^2.

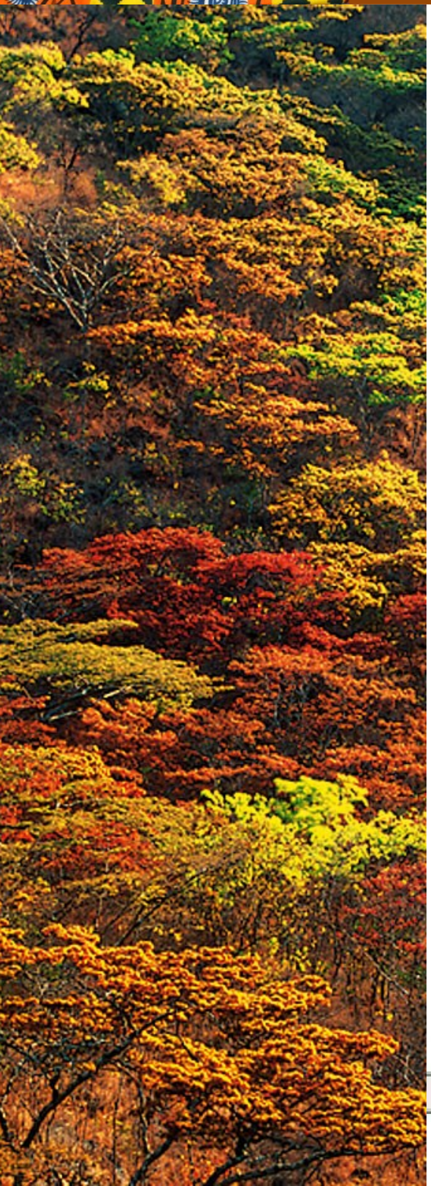


Source: White (1983)

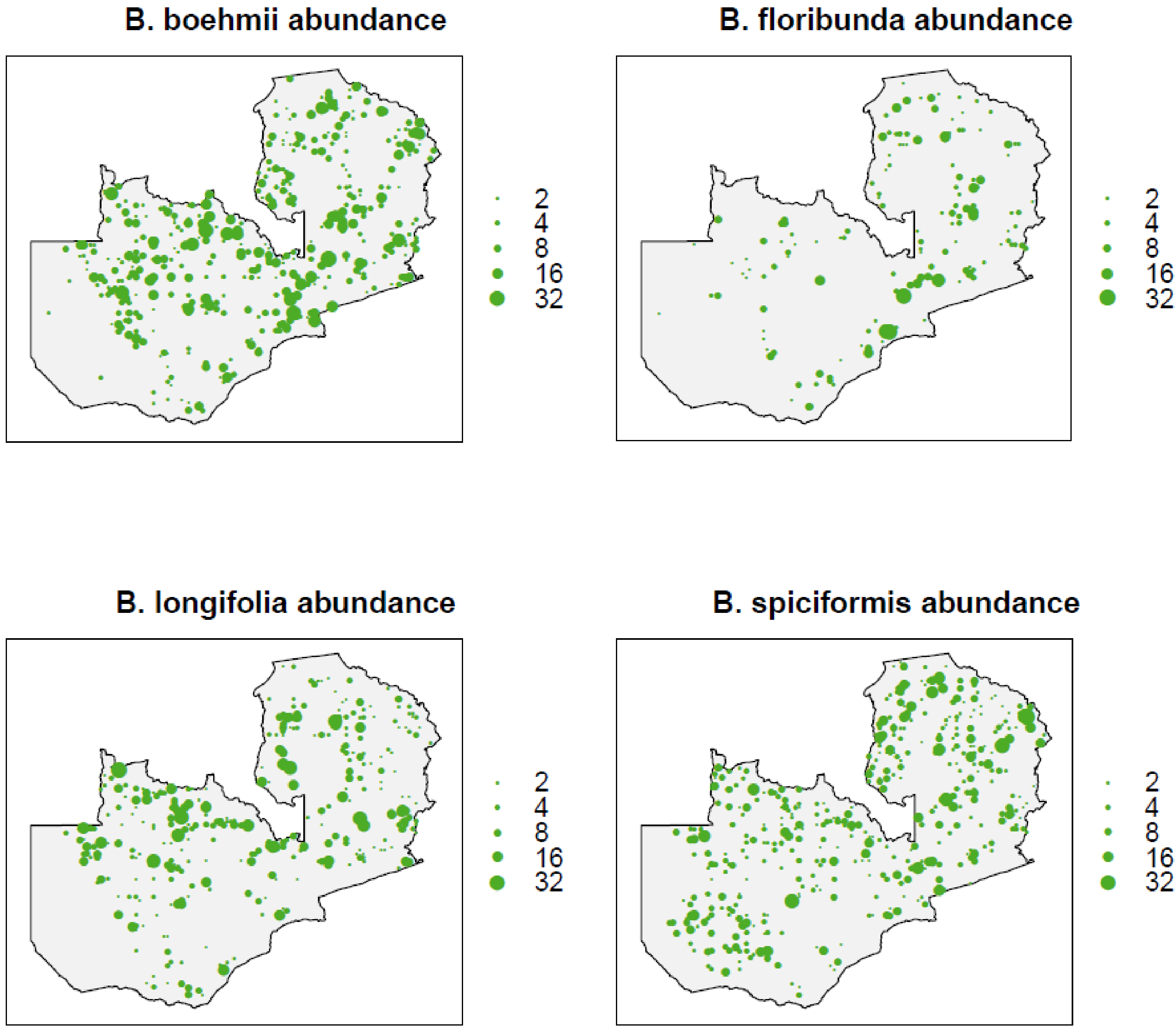
Section 4: Main vegetation types

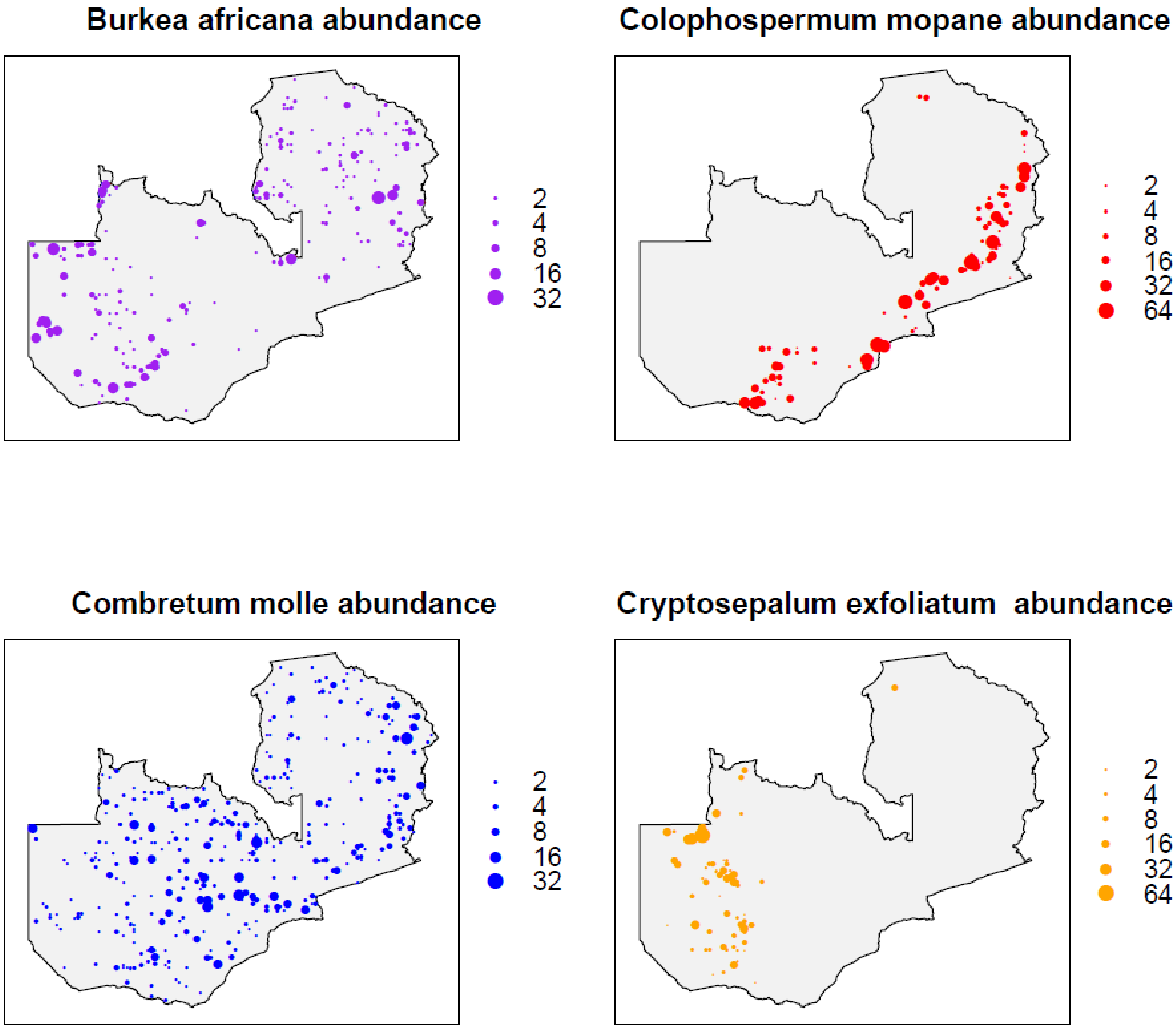


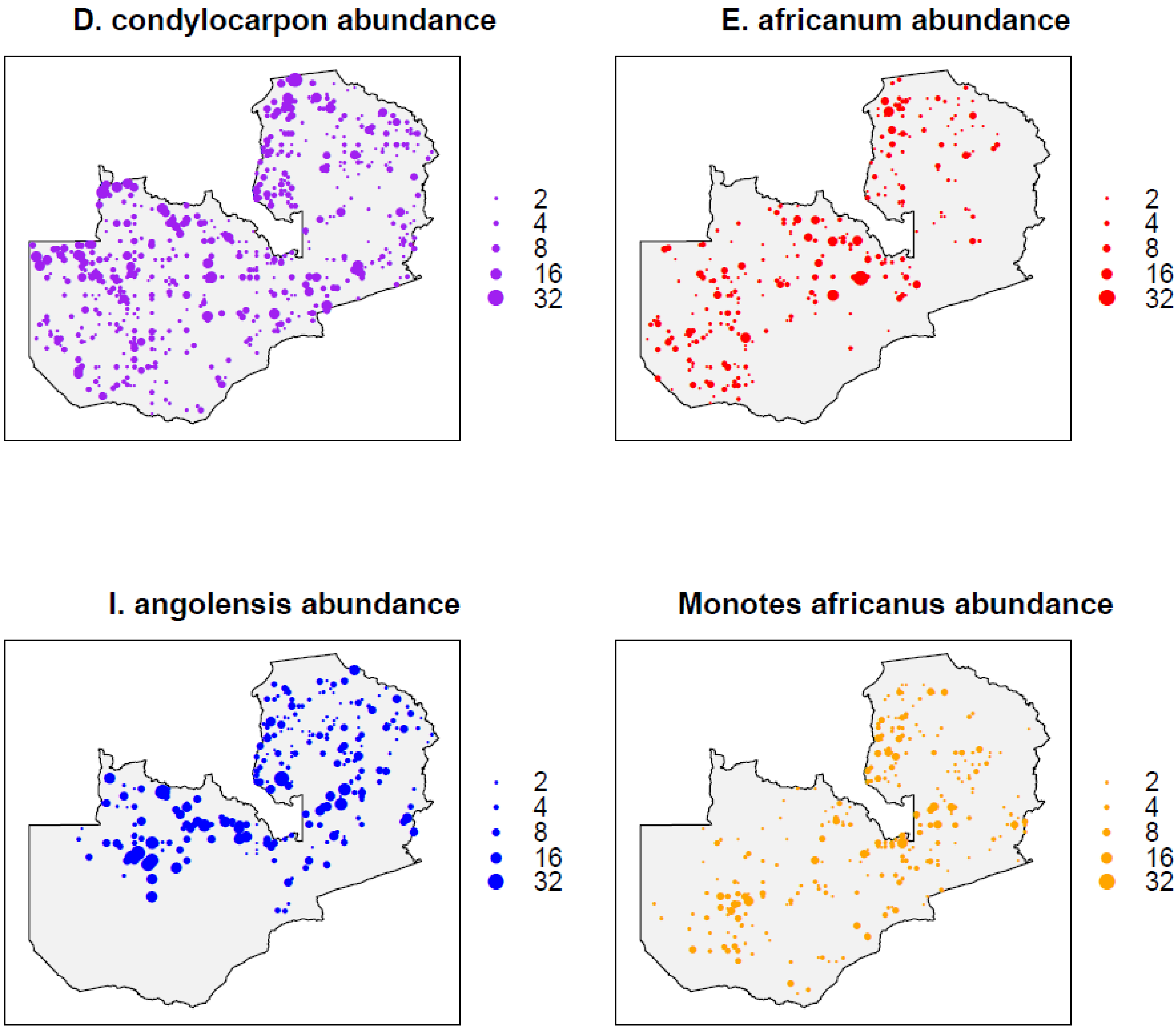
Section 4:Species distribution

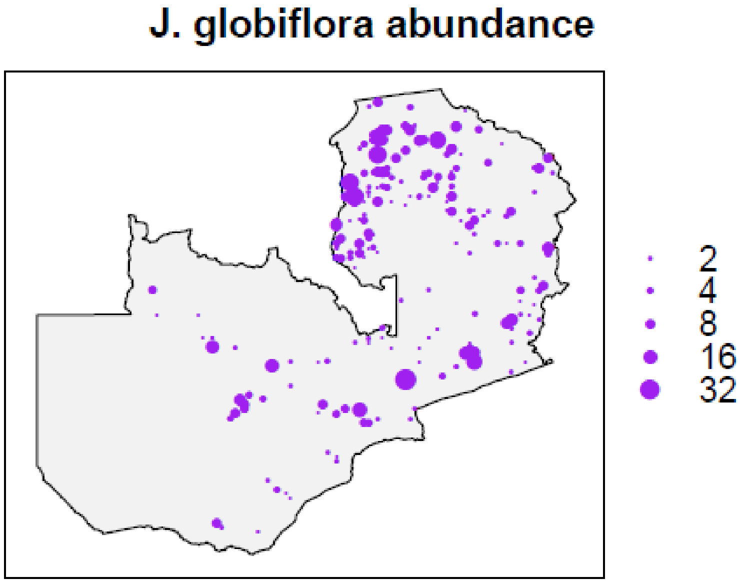


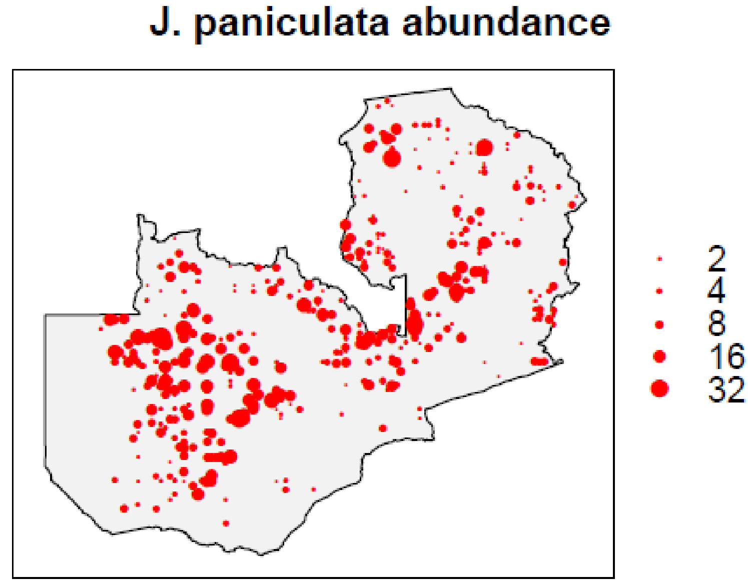
- Provides a baseline for the country and the region
- Allow to make predictions on potential impacts of climate change and other human impacts on biodiversity
- 20 most abundant species- based on ILUA II


B. boehmii abundance
2
4
8
16
32
B. floribunda abundance
2
4
8
16
32
B. longifolia abundance
2
4
8
16
32
B. spiciformis abundance
2
4
8
16
32

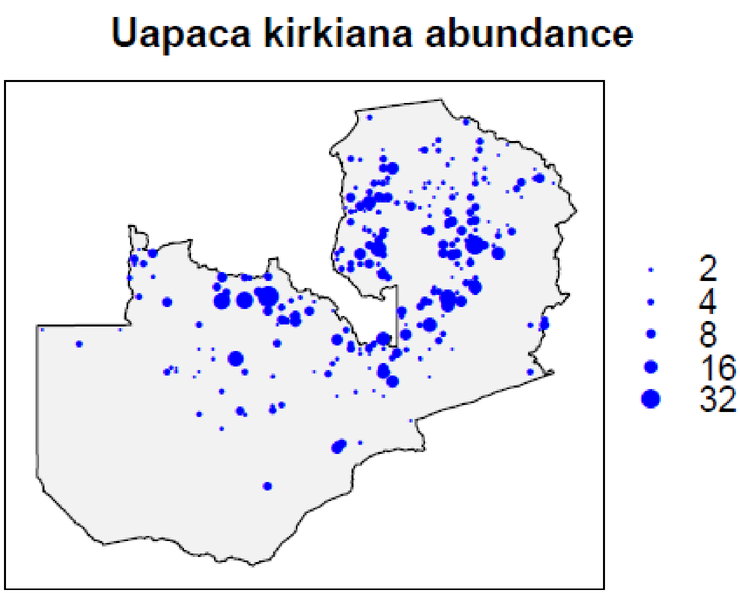

Burkea africana abundance
2
4
8
16
32
Colophospermum mopane abundance
2
4
8
16
32
64
Combretum molle abundance
2
4
8
16
32
Cryptosepalum exfoliatum abundance
2
4
8
16
32
64

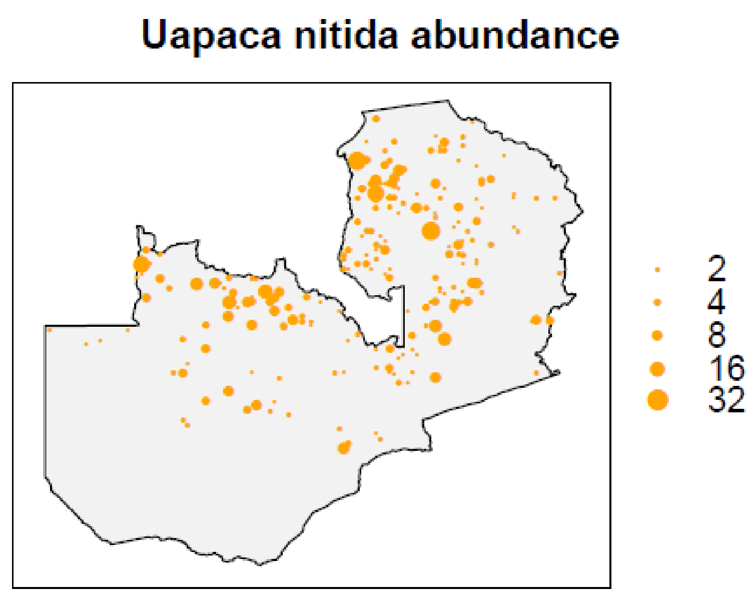

D. condylocarpon abundance
2
4
8
16
32
E. africanum abundance
2
4
8
16
32
I. angolensis abundance
2
4
8
16
32
Monotes africanus abundance
2
4
8
16
32

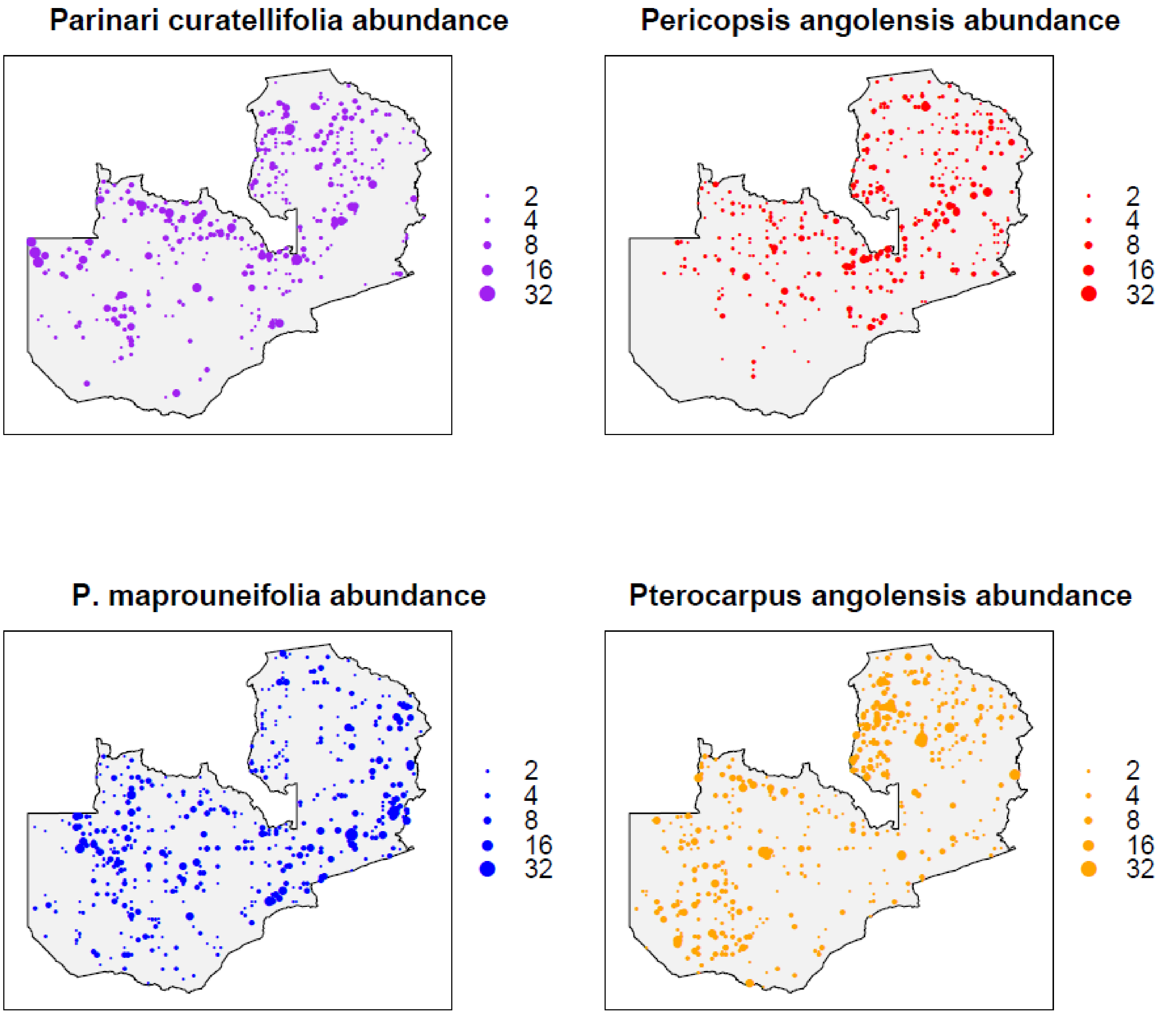




Distribution and modelling of J. globiflora and J. paniculata has been performed by Chidumayo (2017)






Parinari curatellifolia abundance
Pericopsis angolensis abundance
P. maprouneifolia abundance
Pterocarpus angolensis abundance
2
4
8
16
32

Conclusions

- Gain in biomass between the two inventories
- Proxy of human impacts directly affect forest productivity
- Diversity, including the role of dominance (or evenness) and functional diversity is linked to biomass increment

Future work

- Push the analysis of the changes with socio-economic variables (FLES);
- Attribute the change in forest cover to specific human activities (e.g. charcoal production), including fire;
- Advance in species distribution and modelling;
- Build functional and phylogenetic diversity data bases and relate to field measurements

Acknowledgements

- Zambia Forestry Department
- Food and Agriculture Organization
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