p4ges

can paying 4 global ecosystem services reduce poverty?

les paiements pour les services écosystèmiques globaux peuvent-ils réduire la pauvreté?

www.p4ges.org

Digging down to understand deforestation's impacts on ecosystem services from soil.

Dr Alison Cameron

University of Zurich UZH

Queen's University Belfast

PRIFYSGOL BANGOR UNIVERSITY

MADAGASIKARA VOAKAJY

Laboratoire des Radioisotopes Université d'Antananarivo

UNIVERSITY OF Southampton

Université d'Antananarivo ECOLE SUPERIEURE DES SCIENCES AGRONOMIQUES 50e ANNIVERSAIRE 1963-2013

PRIFYSGOL ABERYSTWYTH UNIVERSITY

KING'S College LONDON

CONSERVATION INTERNATIONAL

LEAD AUTHORS: Alison Cameron, Ilja van Meerveld, Herintsitohaina Razakamanarivo

BIODIVERSITY: Elizabeth Finch, Tancredi Caruso, Christian Randrianantoadro, Raphali Andriatsimanarilafy
HYDROLOGY: Ravelona Maafaka, Bob Zwartendijk, Chandra Ghimire, Jaona Lahitiana, Mark Mulligan, Sampurno Bruijnzeel
CARBON: Tantely Razafimbelo, Andry Andriamananjara, Nantenaina Ramboatiana, Riana Andriasoa, Hery Razafimahatratra
REMOTE SENSING: Jennifer Hewson, RasoloheryAndriambolantsoa

p4ges

can paying 4 global ecosystem services reduce poverty?

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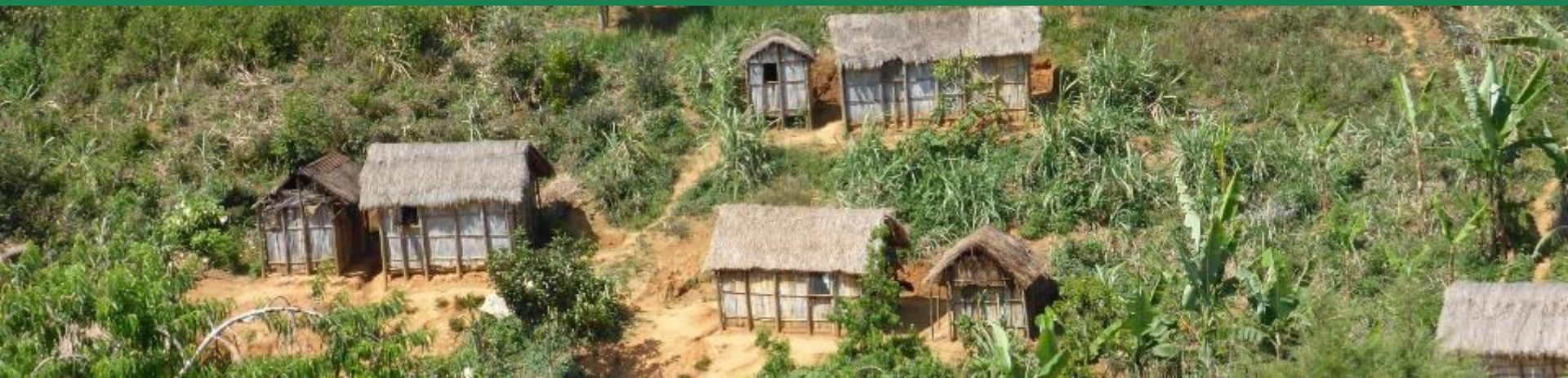
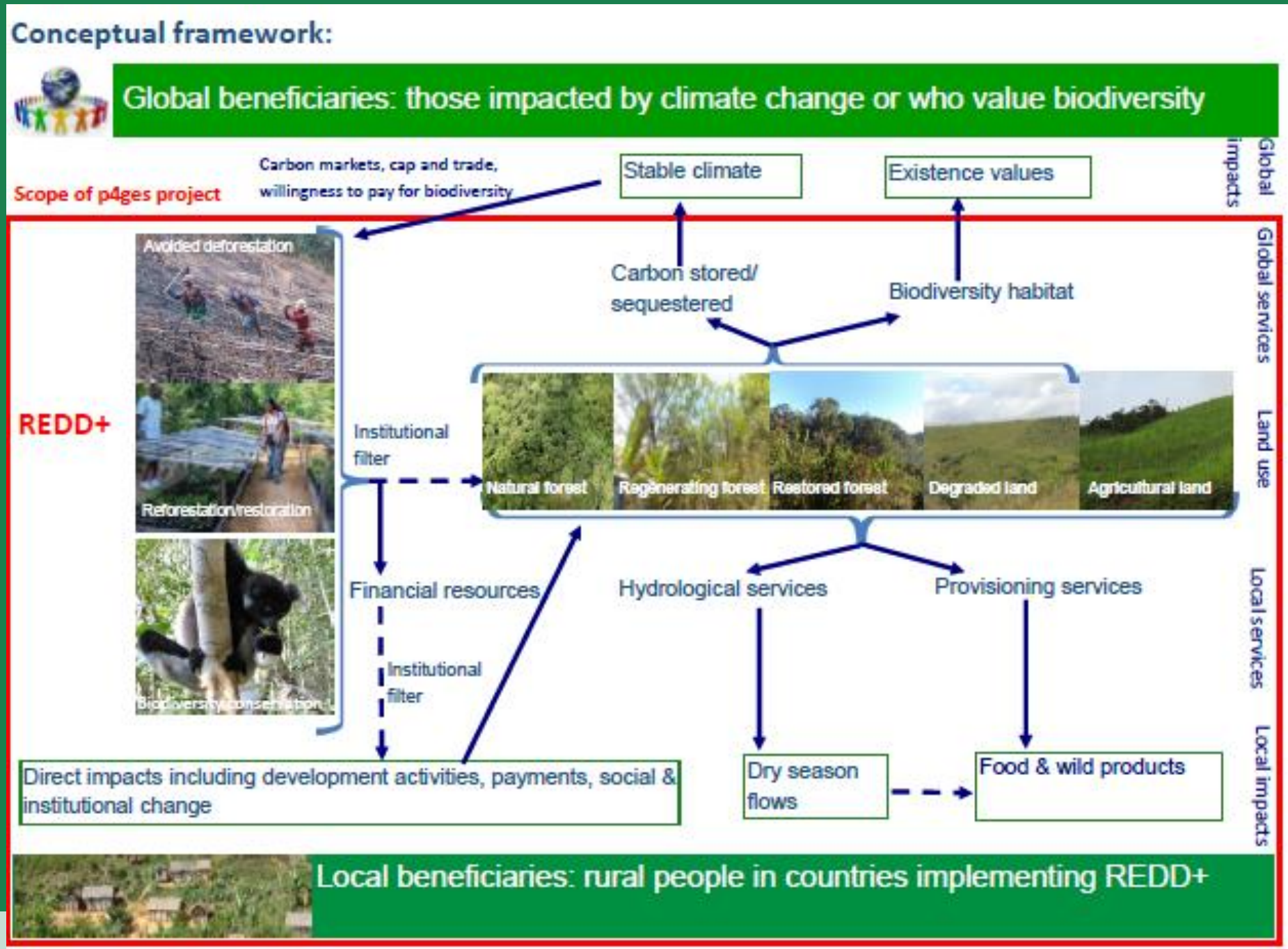
Aim: To influence the development and implementation of international ecosystem service payment schemes (e.g. REDD+) in the interests of poverty alleviation.

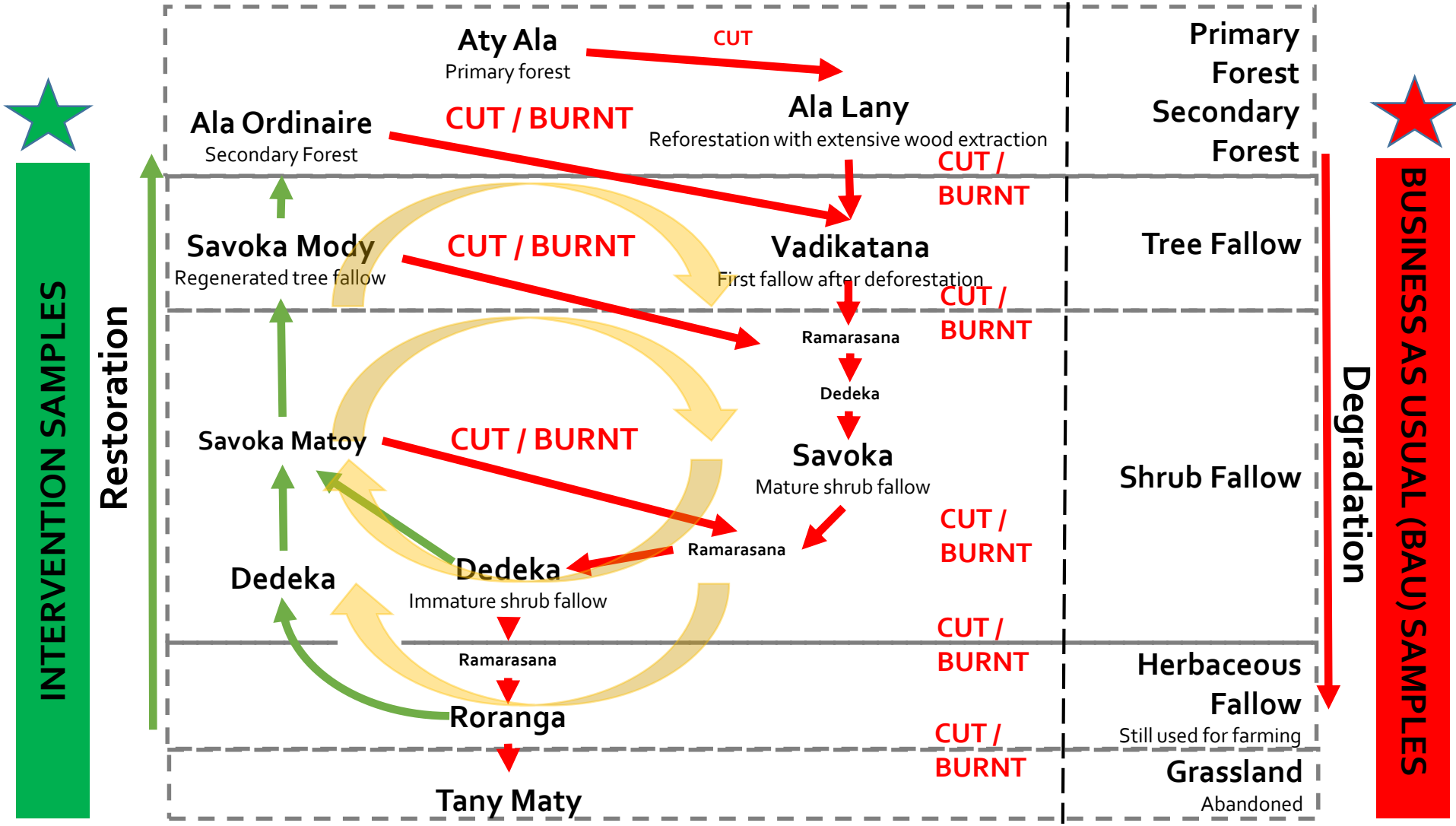


p4ges

Conceptual framework:

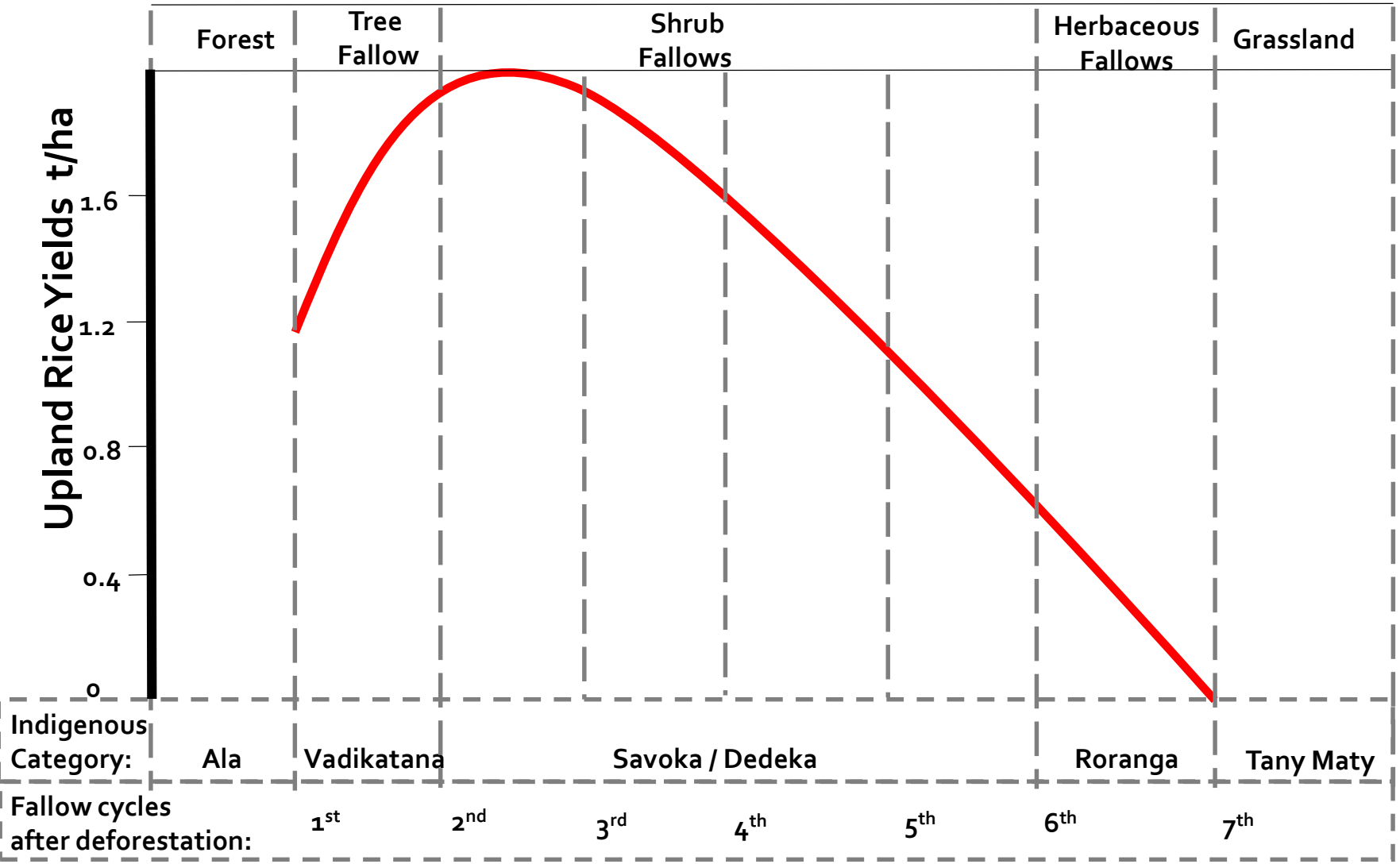


Slash & Burn Agriculture in E Madagascar



Styger *et al.*, (2007). Agriculture, Ecosystems and Environment 119: 257–269

Slash & Burn Agriculture in E Madagascar



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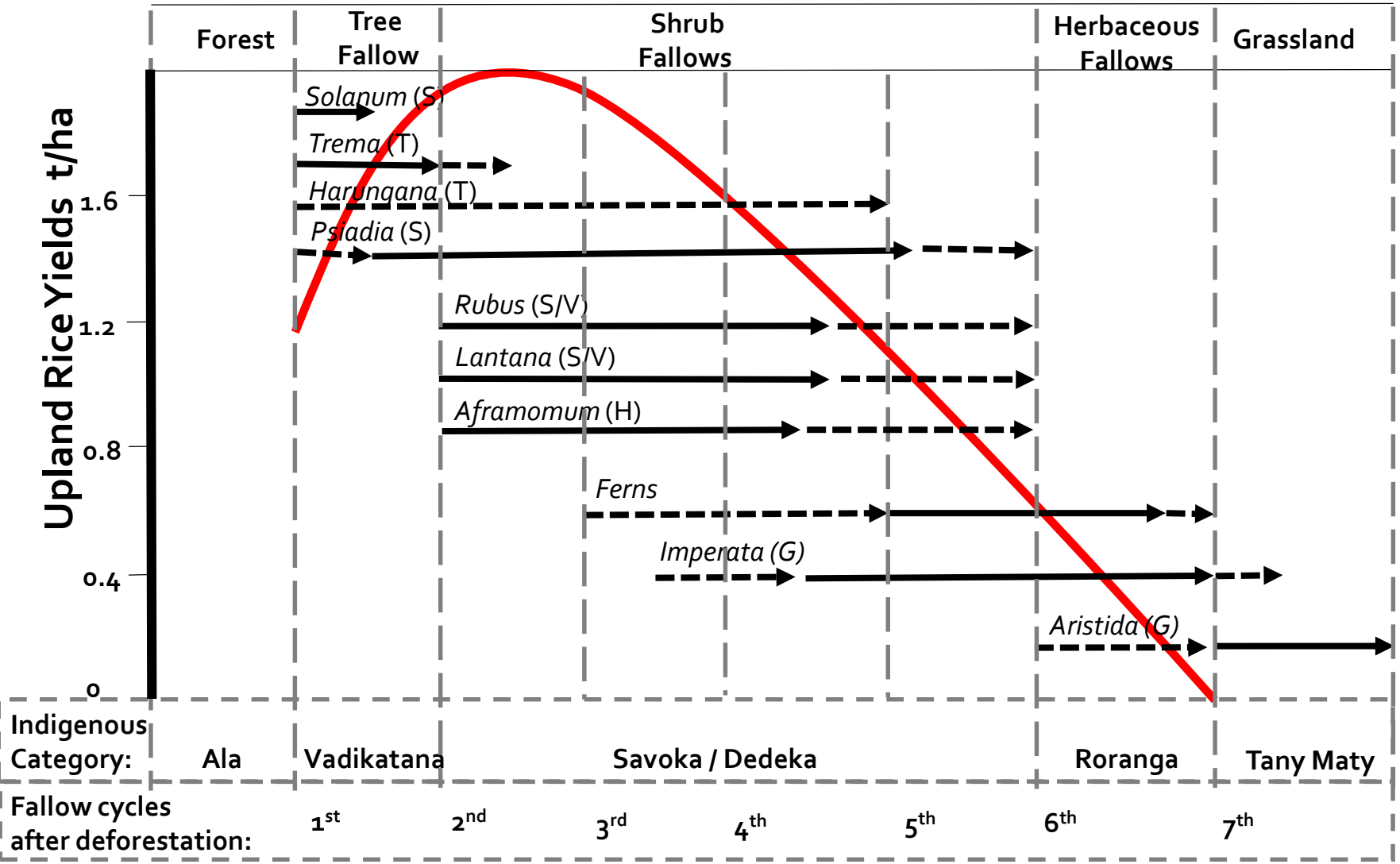
Slash & Burn Agriculture in E Madagascar



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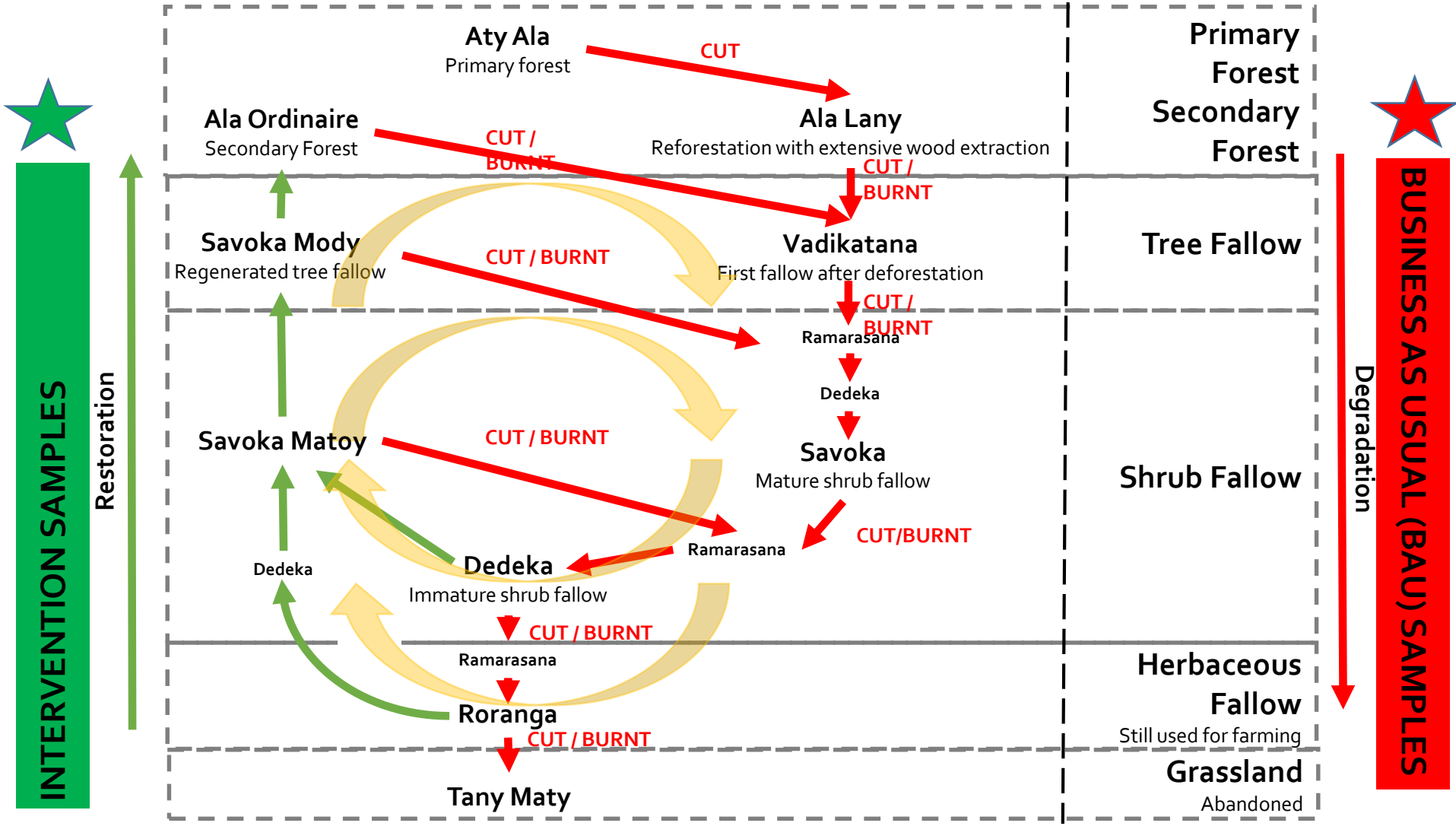
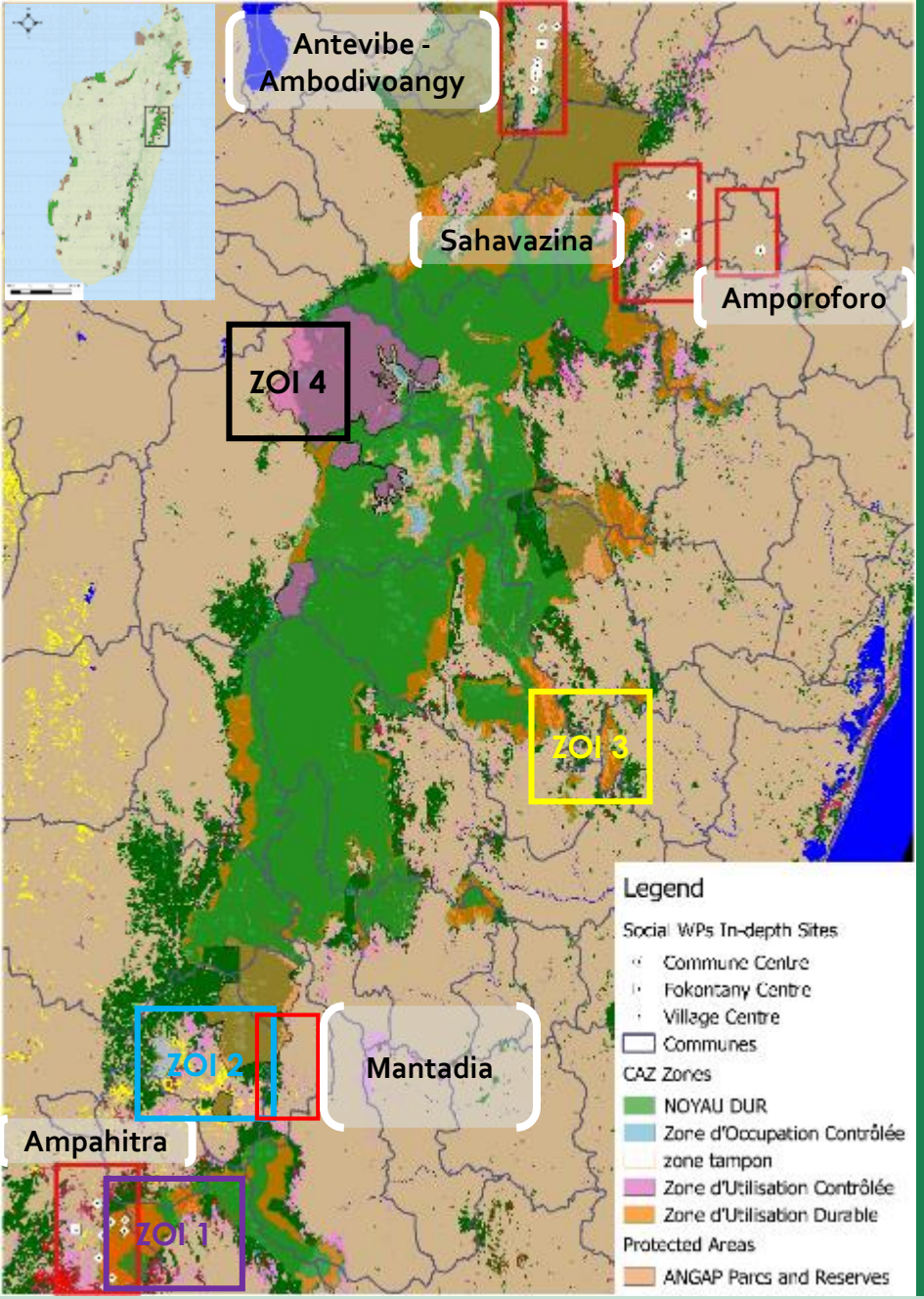
Slash & Burn Agriculture in E Madagascar



Styger *et al.*, (2007). Agriculture, Ecosystems and Environment 119: 257–269


SOILS AND LAND PLAY A FUNDAMENTAL AND CROSS-CUTTING ROLE IN ACHIEVING THE SDGs*
SDG 1: End poverty
SDG 2: Achieve food security
SDG 3: Healthy lives for all
SDG 5: Gender equality
SDG 6: Water for all
SDG 7: Energy for all
SDG 11: Cities
SDG 13: Combat climate change
SDG 15: Protect terrestrial ecosystems
Access and secure rights to productive land
Changes in land use and cover, resulting in sustainable use
Promoting sustainable agriculture and food systems
Halting deforestation, land and soil degradation, and biodiversity loss
Ensuring livelihoods for poor and vulnerable populations
Increased production and consumption of biomass for food, feed, fibre, and fuel
Preventing soil sealing
BASIC SOIL AND LAND SERVICES THAT MUST BE PROTECTED
Carbon storage and contribution to climate change mitigation
Water regulation
Maintaining biodiversity
Nutrient provision and cycling for crop/forest growth and other ecosystems



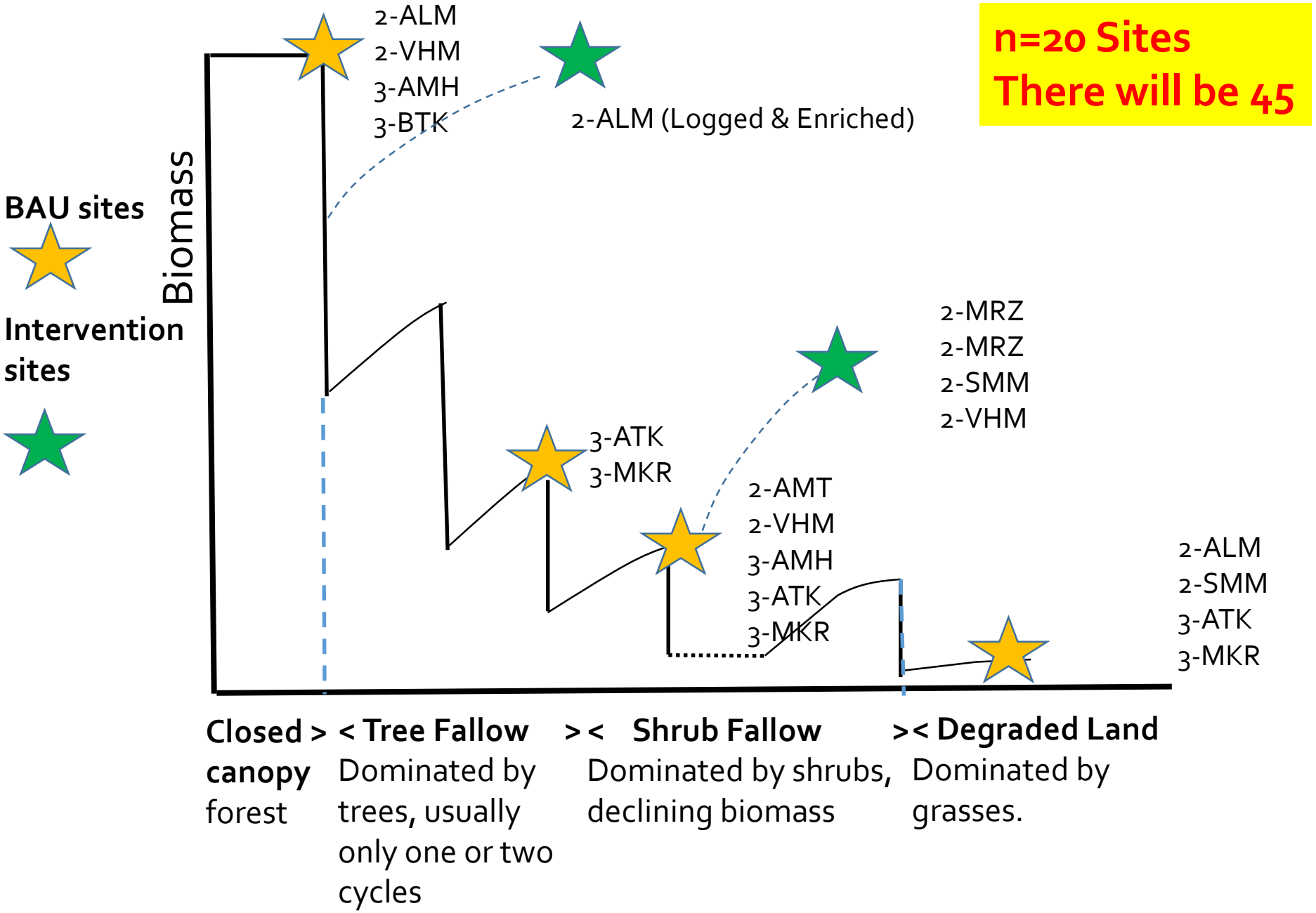
Study sites

~~ZOI1 Carbon Only~~

ZOI2 11/21 sites

ZOI3 9/9 sites

ZOI4 0/15 sites

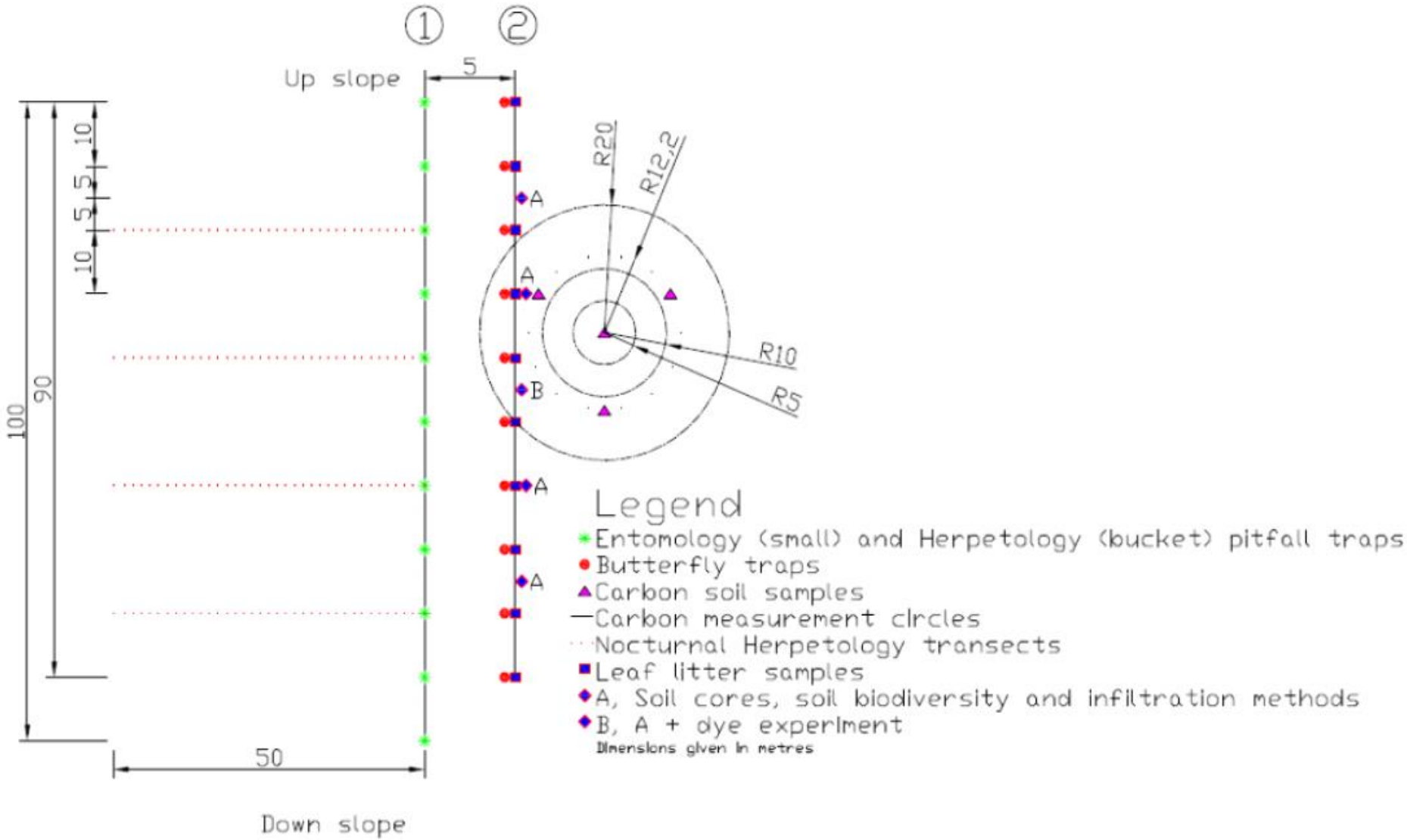

n=20 Sites
There will be 45
BAU sites
Intervention sites
Biomass
2-ALM
2-VHM
3-AMH
3-BTK
2-ALM (Logged & Enriched)
2-MRZ
2-MRZ
2-SMM
2-VHM
3-ATK
3-MKR
2-AMT
2-VHM
3-AMH
3-ATK
3-MKR
2-ALM
2-SMM
3-ATK
3-MKR
Closed > canopy forest
< Tree Fallow
Dominated by trees, usually only one or two cycles
>< Shrub Fallow
Dominated by shrubs, declining biomass
>< Degraded Land
Dominated by grasses.
Time since closed canopy forest disturbance

WP2: Hydrology Sampling

WP4: Carbon Sampling

WP3: Biodiversity Sampling

Site Level Sampling Design

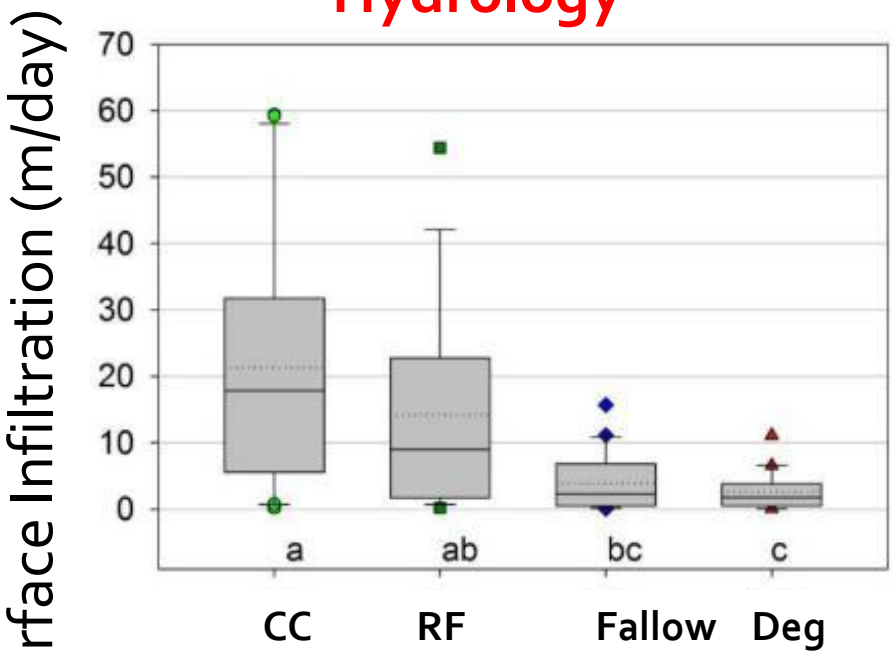


Hydrological Variables

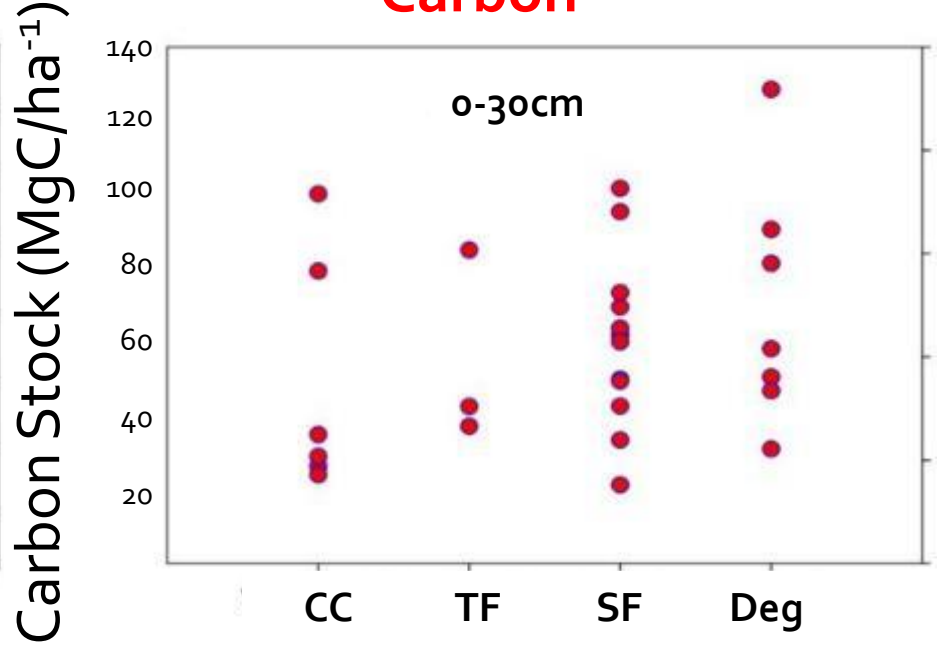
- Transect aspect Degrees
- Transect slope Degrees
- Hydraulic Conductivity (Ksat) 0 0-10cm [mm/hr]
- Bulk density [g/cm³] 12.5 to 17.5 cm
- Porosity [%] 12.5 to 17.5 cm
- Moisture content at field capacity [%] 12.5 to 17.5 cm
- Drainable porosity [%] 12.5 to 17.5 cm
- Root/litter layer cm above the soil surface
- Max. rooting depth cm below the soil surface

Below ground

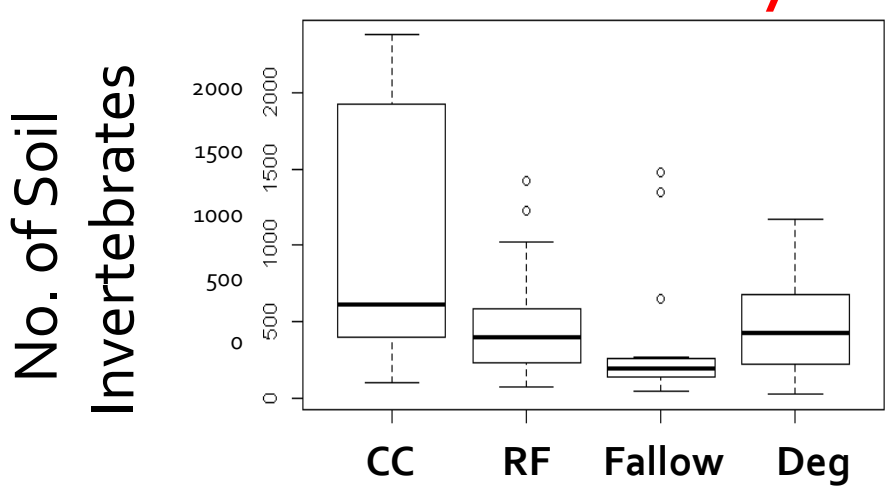
Hydrology



Carbon



Biodiversity



Land Use Codes

CC = Closed Canopy
TS = Tree Fallow
SF = Shrub Fallow
Deg = Degraded
RF = Reforested

When we have a lot of variables,
we can use Multi-variate statistics
to explore relationships between variables.

Example similarity matrix (20 sites x 20 sites)
Envl = Eclidian Distance
Bio = Bray Curtis Distance

Samples

	ALM_CC	ALM_RF1(CC	ALM_TM	AMT_SSA1																		CC1
ALM_CC																						
ALM_RF1(CC)	75.227																					
ALM_TM	75.327	74.482																				
AMT_SSA1	71.482	69.768	63.752																			
MRZ_RF1	67.858	71.96	58.75	75.11																		
MRZ_RF2	74.621	77.012	77.195	67.4																		
SMM_RF	46.492	53.336	40.68	57.65																		
SMM_TM2	54.145	57.911	51.901	69.57																		
VHM_CC	59.801	52.321	43.377	61.19																		
VHM_RF	71.649	71.011	64.077	76.54																		
VHM_TSA	50.601	51.831	41.393	63.17																		
AMH_CC1	54.448	59.559	50.038	69.2																		
AMH_SSA1	48.335	49.359	36.882	59.67																		
ATK_SSA1	50.888	61.538	67.245	56.43																		
ATK_TM1	48.822	51.152	61.73	44.58																		
ATK_TSA1	65.374	59.608	72.787	60.79																		
BTK_CC1	61.77	67.254	68.553	57.80																		
MKR_SSA1	58.053	60.497	68.369	61.05																		66.304
MKR_TM1	45.471	53.609	52.992	40.15																		69.954
MKR_TSA1	39.325	40.741	54.449	37.04																		62.843

Samples

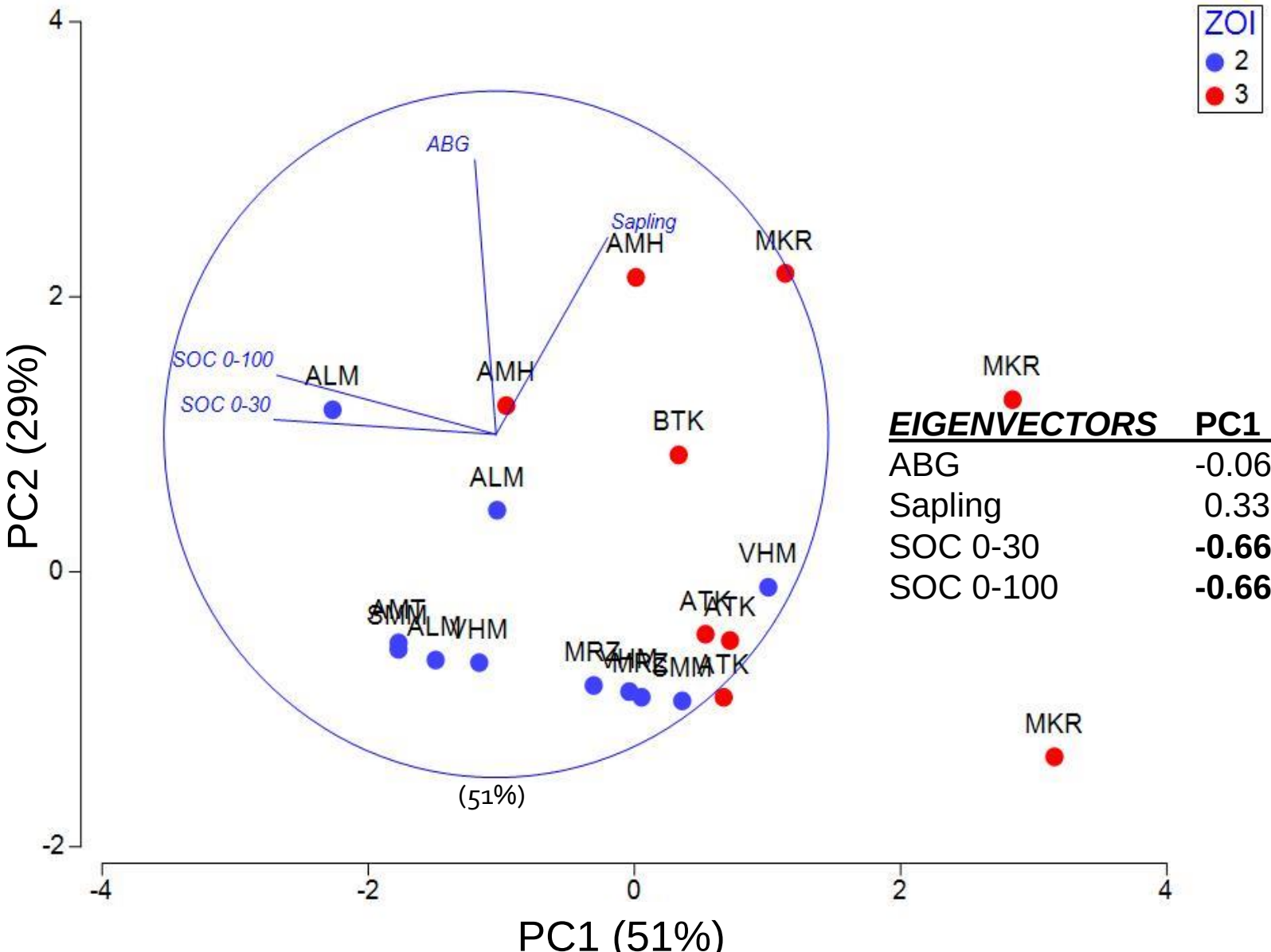
	ALM_CC	ALM_RF1(CC	ALM_TM	AMT_SS
ALM_CC				
ALM_RF1(CC)	75.227			
ALM_TM	75.327	74.482		
AMT_SSA1	71.482	69.768	63.752	
MRZ_RF1	67.858	71.96	58.75	75
MRZ_RF2	74.621	77.012	77.195	6
SMM_RF	46.492	53.336	40.68	57
SMM_TM2	54.145	57.911	51.901	69
VHM_CC	59.801	52.321	43.377	61

Principal Component Analysis (PCA)

Determining principal components of the variation within individual multi-variate data sets

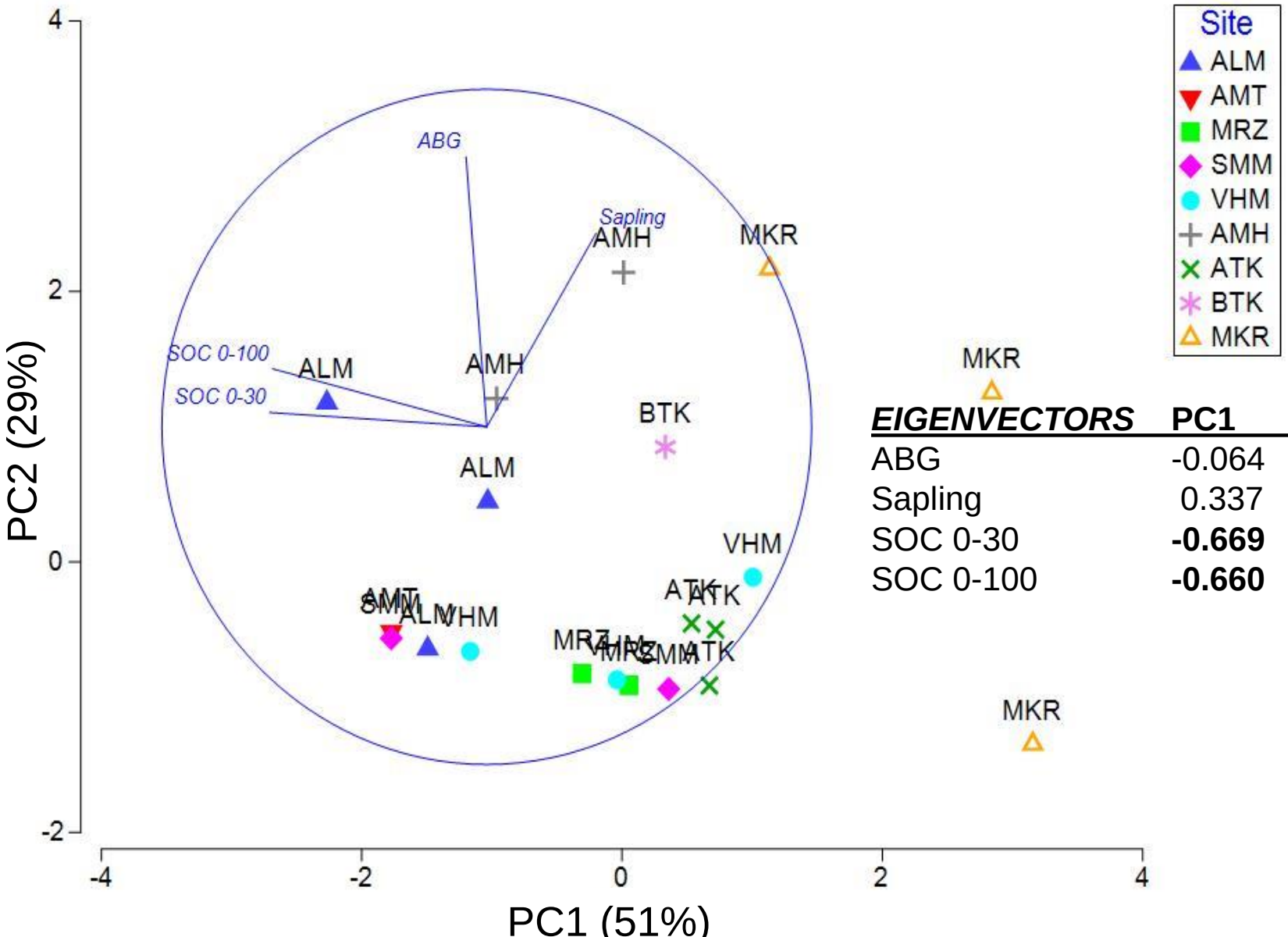
NOT A TEST OF SIGNIFICANCE

Principal Component Analysis Carbon (4 Variables)



EIGENVECTORS	**PC1**	**PC2**
ABG	-0.064	**0.800**
Sapling	0.337	**0.574**
SOC 0-30	**-0.669**	0.042
SOC 0-100	**-0.660**	0.172

Principal Component Analysis Carbon (4 Variables)



EIGENVECTORS	**PC1**	**PC2**
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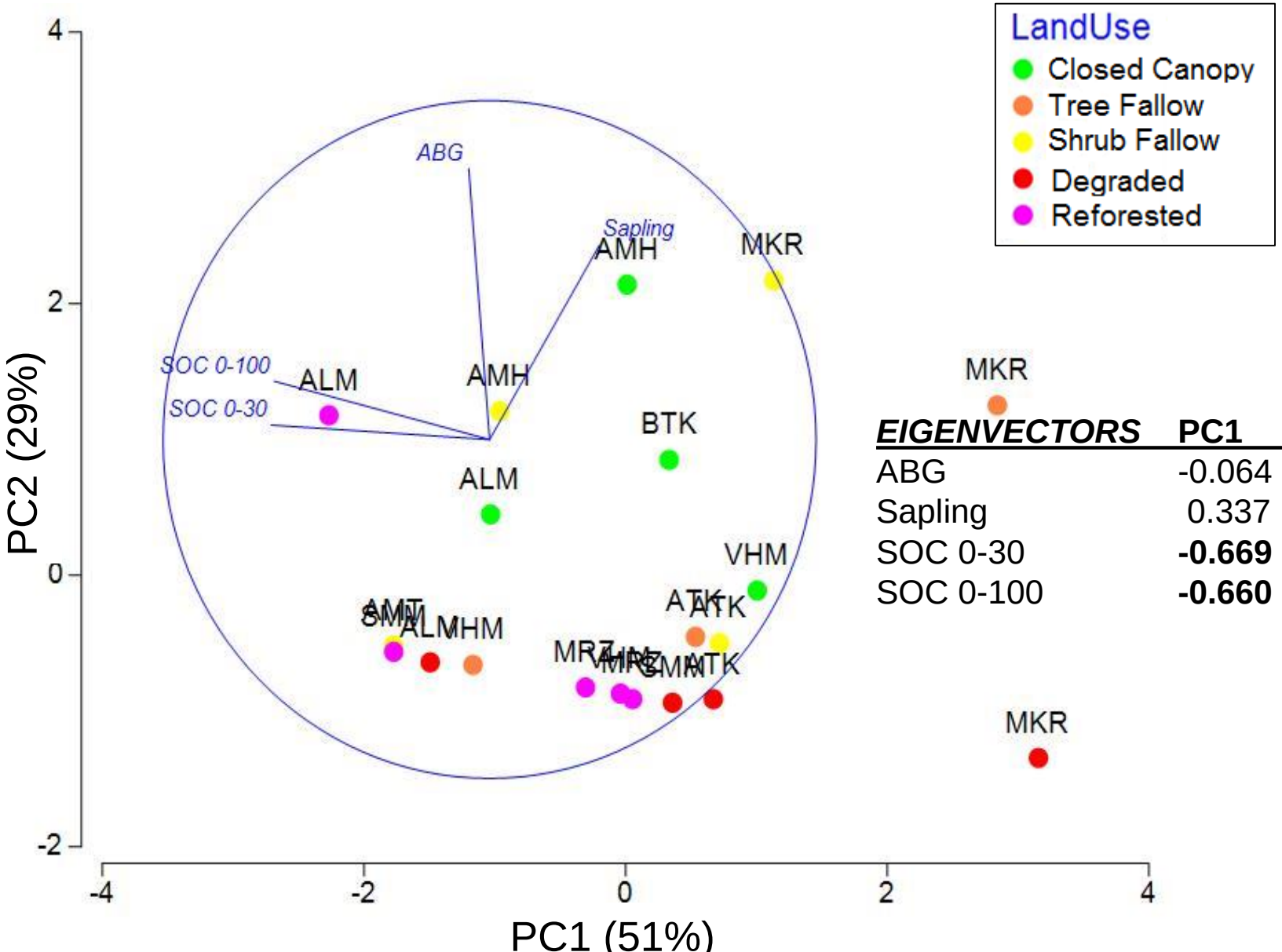
Principal Component Analysis Carbon (4 Variables)



EIGENVECTORS	**PC1**	**PC2**
ABG	-0.064	**0.800**
Sapling	0.337	**0.574**
SOC 0-30	**-0.669**	0.042
SOC 0-100	**-0.660**	0.172

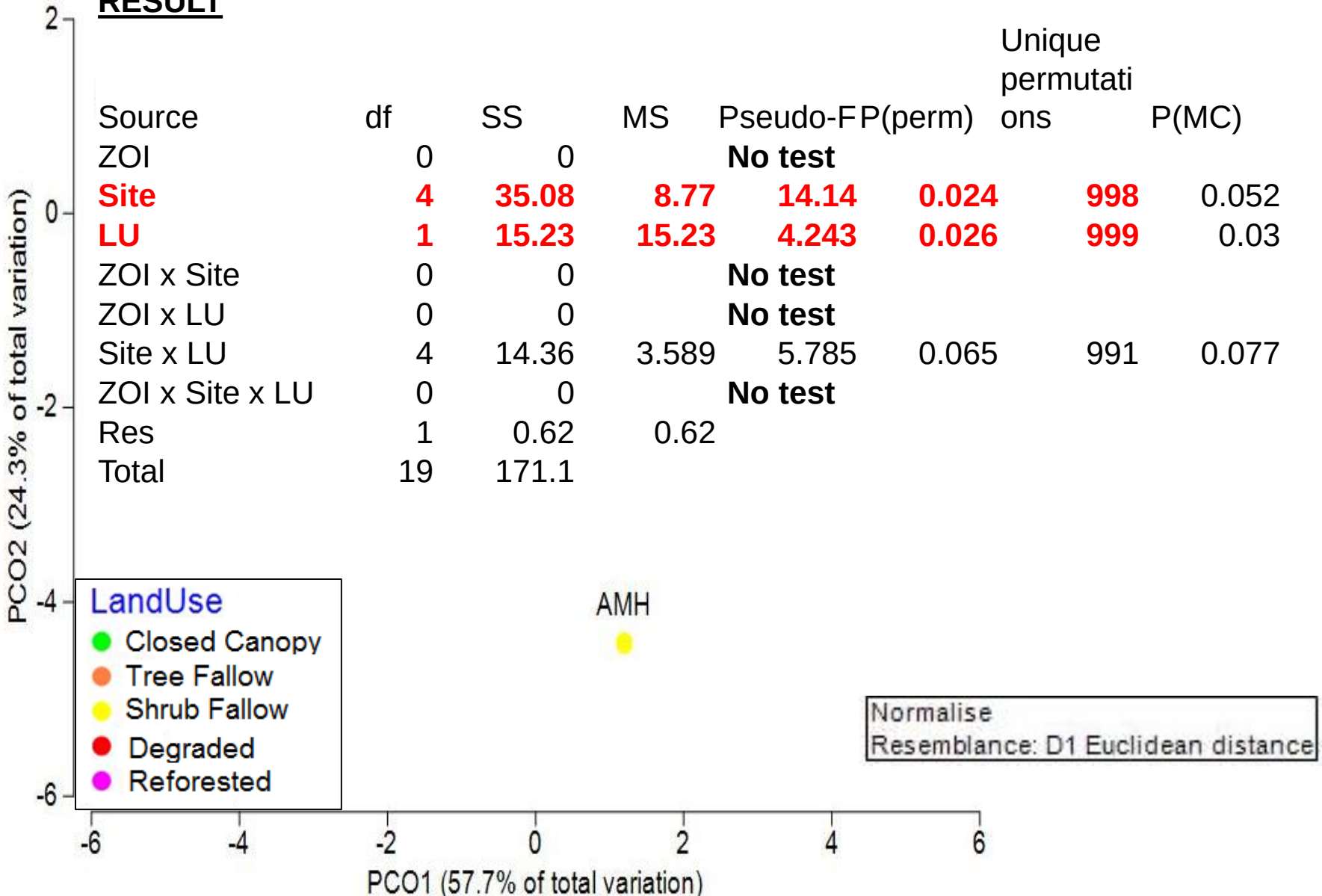
Principal Component Ordination (PCO)

CAN USE PERMANOVA TO TEST FOR DIFFERENCES BETWEEN GROUPS AND INTERACTIONS

Principal Component Ordination Carbon (4 Variables)

PERMANOVA RESULT

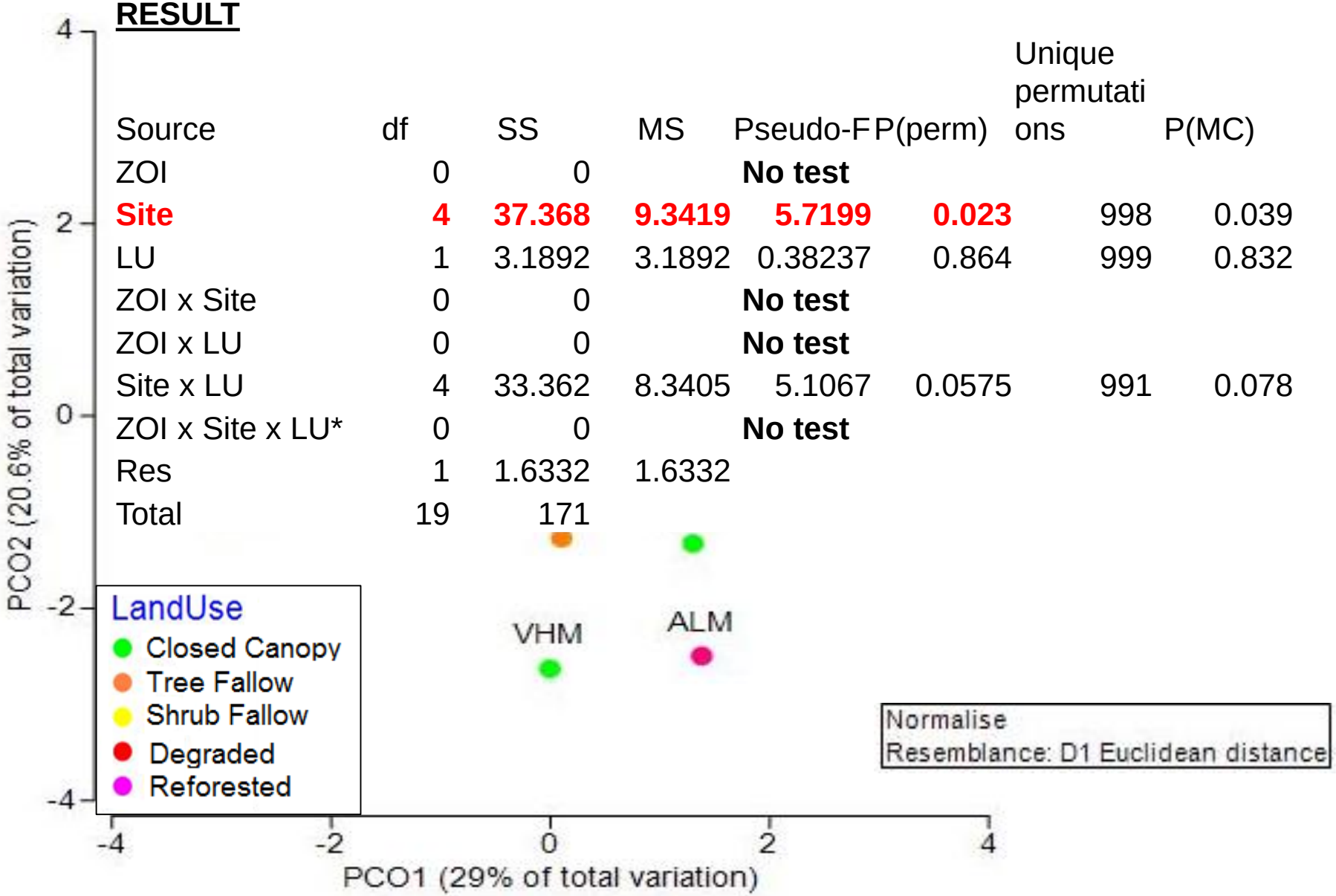
Source	df	SS	MS	Pseudo-F	P(perm)	Unique permutations	P(MC)
ZOI	0	0		**No test**			
Site	**4**	**35.08**	**8.77**	**14.14**	**0.024**	**998**	0.052
LU	**1**	**15.23**	**15.23**	**4.243**	**0.026**	**999**	0.03
ZOI x Site	0	0		**No test**			
ZOI x LU	0	0		**No test**			
Site x LU	4	14.36	3.589	5.785	0.065	991	0.077
ZOI x Site x LU	0	0		**No test**			
Res	1	0.62	0.62				
Total	19	171.1					



Principal Component Ordination Hydrology (9 Variables)

PERMANOVA RESULT

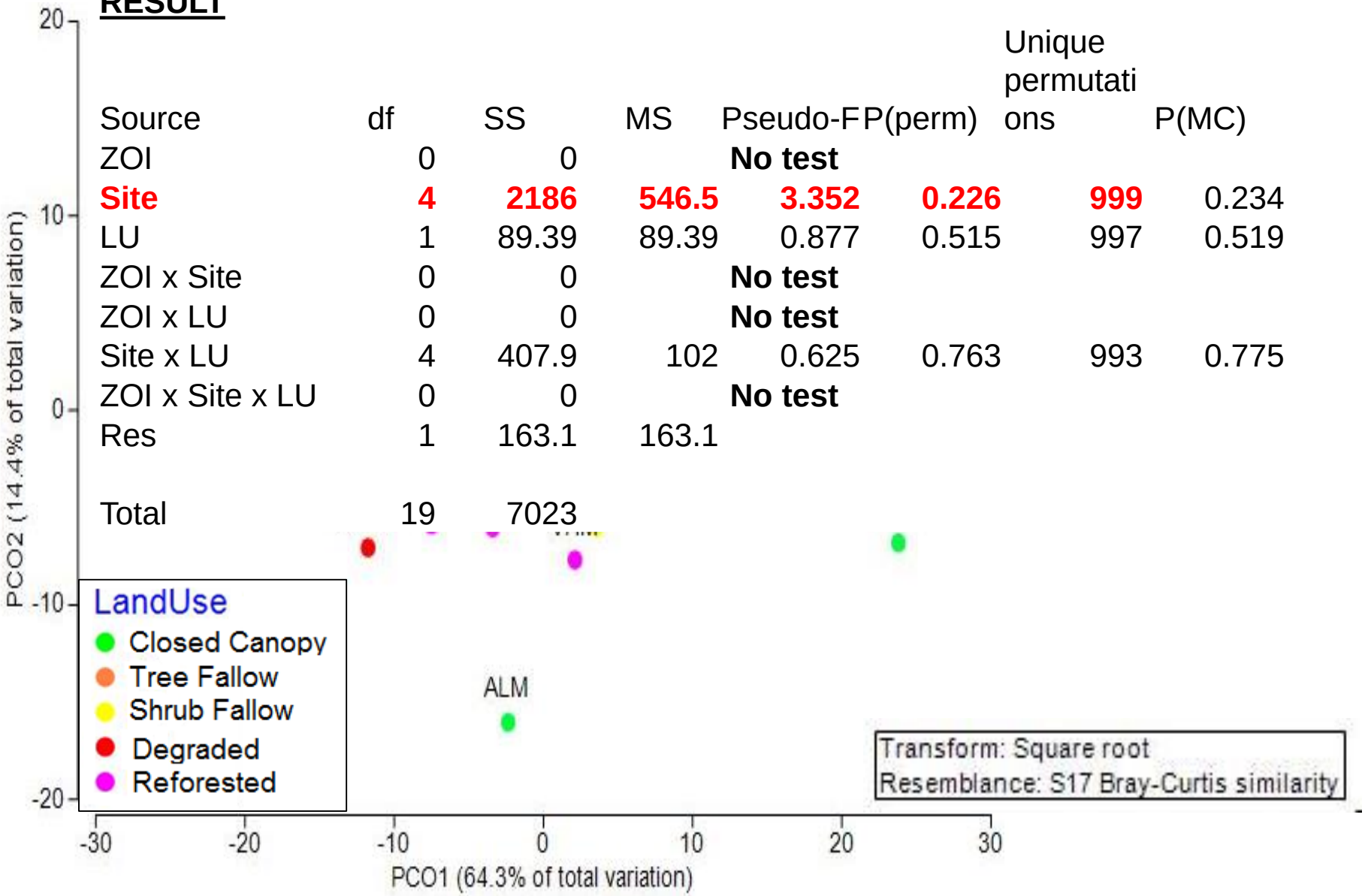
Source	df	SS	MS	Pseudo-F	P(perm)	Unique permutations	P(MC)
ZOI	0	0		**No test**			
Site	**4**	**37.368**	**9.3419**	**5.7199**	**0.023**	998	0.039
LU	1	3.1892	3.1892	0.38237	0.864	999	0.832
ZOI x Site	0	0		**No test**			
ZOI x LU	0	0		**No test**			
Site x LU	4	33.362	8.3405	5.1067	0.0575	991	0.078
ZOI x Site x LU*	0	0		**No test**			
Res	1	1.6332	1.6332				
Total	19	171					



Principal Component Ordination Biodiversity (17 Variables)

PERMANOVA RESULT

Source	df	SS	MS	Pseudo-F	P(perm)	Unique permutations	P(MC)
ZOI	0	0		**No test**			
Site	**4**	**2186**	**546.5**	**3.352**	**0.226**	**999**	0.234
LU	1	89.39	89.39	0.877	0.515	997	0.519
ZOI x Site	0	0		**No test**			
ZOI x LU	0	0		**No test**			
Site x LU	4	407.9	102	0.625	0.763	993	0.775
ZOI x Site x LU	0	0		**No test**			
Res	1	163.1	163.1				
Total	19	7023					



Exploring relationships between two multi-variate data sets

A) Test ("Relate") Patterns in 2 Similarity Matrices

Example similarity matrix (20 sites x 20 sites)
Envl = Eclidian Distance
Bio = Bray Curtis Distance

Samples

	ALM_CC	ALM_RF1(CC	ALM_TM	AMT_SSA1	MRZ_RF1	MRZ_RF2	SMM_RF	SMM_TM2	VHM_CC	VHM_RF	VHM_TSA	AMH_CC1	AMH_SSA1	ATK_SSA1	ATK_TM1	ATK_TSA1	BTK_CC1
ALM_CC																	
ALM_RF1(CC)	75.227																
ALM_TM	75.327	74.482															
AMT_SSA1	71.482	69.768	63.752														
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MRZ_RF2	74.621	77.012	77.195	67.47	69.522												
SMM_RF	46.492	53.336	40.68	57.652	69.346	45.612											
SMM_TM2	54.145	57.[illegible]															
VHM_CC	59.801	52.[illegible]															
VHM_RF	71.649	71.[illegible]															
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AMH_CC1	54.448	59.[illegible]															
AMH_SSA1	48.335	49.[illegible]															
ATK_SSA1	50.888	61.[illegible]															
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BTK_CC1	61.77	67.[illegible]															
MKR_SSA1	58.053	60.[illegible]															
MKR_TM1	45.471	53.[illegible]															
MKR_TSA1	39.325	40.[illegible]															

Samples

	ALM_CC	ALM_RF1(CC	ALM_TM	AMT_SSA1	MRZ_RF1	MRZ_RF2	SMM_RF	SMM_TM2	VHM_CC	VHM_RF	VHM_TSA	AMH_CC1	AMH_SSA1	ATK_SSA1	AT
ALM_CC															
ALM_RF1(CC)	75.227														
ALM_TM	75.327	74.482													
AMT_SSA1	71.482	69.768	63.752												
MRZ_RF1	67.858	71.96	58.75	75.114											
MRZ_RF2	74.621	77.012	77.195	67.47	69.522										
SMM_RF	46.492	53.336	40.68	57.652	69.346	45.612									
SMM_TM2	54.145	57.911	51.901	69.572	78.122	56.593	77.698								
VHM_CC	59.801	52.321	43.377	61.191	66.613	50.055	73.512	68.878							
VHM_RF	71.649	71.011	64.077	76.548	74.55	72.947	54.986	65.848	64.666						
VHM_TSA	50.601	51.831	41.393	63.177	66.501	48.68	81.467	71.022	72.7	61.781					
AMH_CC1	54.448	59.559	50.038	69.27	70.3	52.941	73.788	69.429	66.8	63.155	76.985				
AMH_SSA1	48.335	49.359	36.882	59.676	68.17	44.299	82.618	70.274	80.781	55.115	81.832	71.43			
ATK_SSA1	50.888	61.538	67.245	56.438	53.431	67.073	34.371	42.894	33.097	57.785	38.327	39.047	34.112		
ATK_TM1	48.822	51.152	61.73	44.586	47.892	61.52	33.591	40.568	32.358	47.998	36.205	44.296	29.969	71.613	
ATK_TSA1	65.374	59.608	72.787	60.791	55.108	59.628	37.317	45.52	41.919	63.391	40.613	45.694	33.292	57.021	
BTK_CC1	61.77	67.254	68.553	57.802	62.786	75.629	44.782	55.42	45.426	60.235	44.456	55.711	39.199	56.874	
MKR_SSA1	58.053	60.497	68.369	61.058	50.359	66.084	35.904	41.637	38.71	55.945	36.194	40.694	30.473	72.602	
MKR_TM1	45.471	53.609	52.992	40.156	45.912	60.385	32.096	35.624	32.264	47.49	38.509	41.801	28.639	62.453	
MKR_TSA1	39.325	40.741	54.449	37.049	37.732	48.375	25.507	31.603	24.901	37.031	26.689	38.294	22.621	65.437	

Exploring relationships between two multi-variate data sets

A) **Test ("Relate") Patterns in 2 Similarity Matrices**
B) **Distance Based Linear Models of Biological Data from Physical Data**

Distance Based Linear Model: Relationship between Biodiversity and Carbon

Spearman's Rank Correlation

Rho 0.267 (weak)

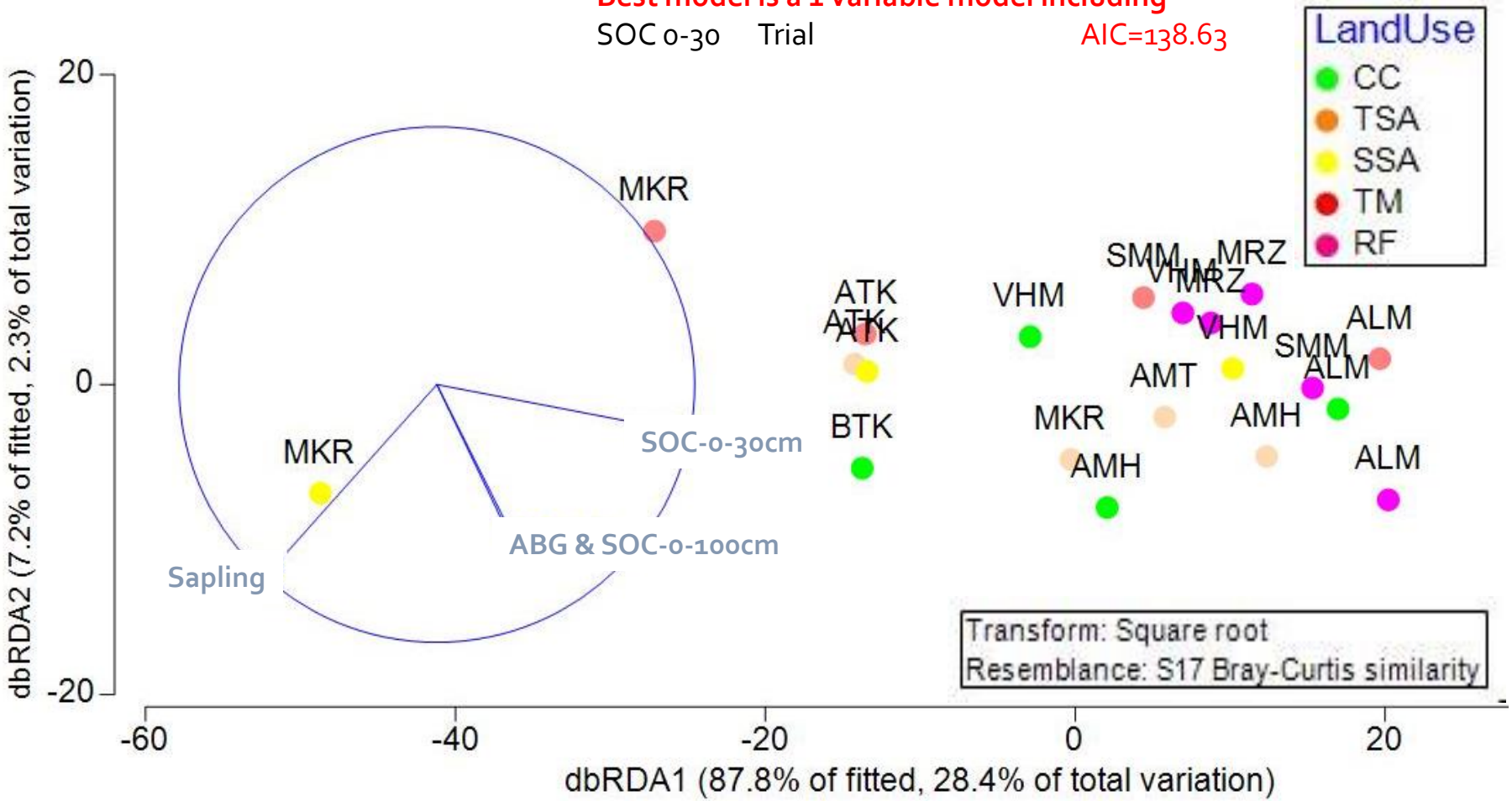
Significance **0.04%** (significant)

Three variables identified as significant individual predictors

Variable	SS(trace)	Pseudo-F	P	Prop.
Sapling	2820.8	2.911	**0.027**	0.13921
SOC 0-30	4072.3	4.5274	**0.005**	0.20097
SOC 0-100	2830.2	2.9224	**0.027**	0.13968
ABG	543.79	0.49639	0.765	0.026837

Best model is a 1 variable model including

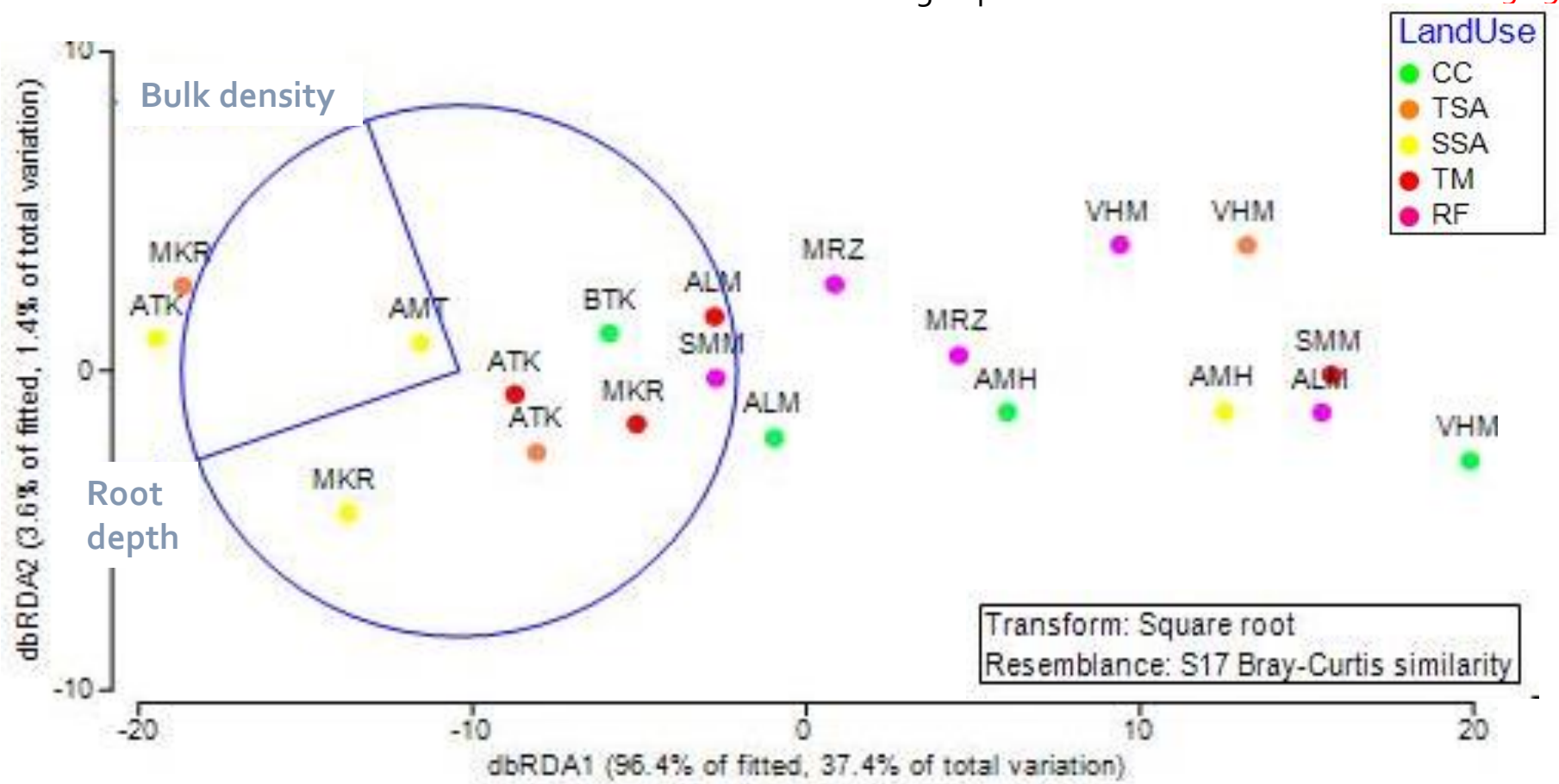
SOC 0-30 Trial AIC=138.63



Distance Based Linear Model: Relationship between Biodiversity and Hydrology

Spearman's Rank Correlation
Rho 0.224 (weak)
Significance **1.2%** (significant)

Only one of 9 variables identified as significant individual predictor
Max. rooting depth cm below the soil surface P=0.003
Best model is a 2 variable model including
Bulk density [g/cm³] 12.5 to 17.5 cm
Max. rooting depth cm below the soil surface AIC =115.19



espa
ecosystem services
for poverty alleviation

A research programme co-funded by DFID, NERC & ESRC and accredited by LWEC

UKaid
from the British people

NERC
SCIENCE OF THE ENVIRONMENT

E·S·R·C
ECONOMIC & SOCIAL RESEARCH COUNCIL

Annual Report: The importance of soils and soil processes is being recognised in a growing number of projects.

A horizon scan of global conservation issues for 2013

William J. Sutherland[1], Sarah Bardsley[2], Mick Clout[3], Michael H. Depledge[4], Lynn V. Dicks[1], Liz Fellman[5], Erica Fleishman[6], David W. Gibbons[7], Brandon Keim[8], Fiona Lickorish[9], Ceri Margerison[10], Kathryn A. Monk[11], Kenneth Norris[12], Lloyd S. Peck[13], Stephanie V. Prior[1], Jörn P.W. Scharlemann[14,15], Mark D. Spalding[16], and Andrew R. Watkinson[17]

Species loss as a driver of global environmental change

Next steps

- Include more sites (from 20 to 45)
- Account for spatial autocorrelation
- Split sites into degrading/recovering
- Explore above <> below ground relationships
- Include more carbon variables (e.g. dead wood)
- Higher resolution on biodiversity (meta-genomics)
- Functional diversity

Acknowledgements


CALROSE RICE