Can we REALLY learn anything more about elephant impacts?

Angela Gaylard[*+], Kevin Rogers[+]
& Norman Owen-Smith[+]

[*]SANParks, [+]Wits University (Centre for Water in the Environment, Centre for African Ecology)

Elephant impacts have been

- a recurring theme at previous Network Meetings
- very well documented in the literature
- summarised for Kruger in the Kruger book (du Toit, Biggs & Rogers 2003)
- summarised for South Africa in the Elephant Assessment (Scholes & Mennell 2008)

SO IS THERE REALLY ANYTHING MORE WE CAN LEARN ABOUT ELEPHANT IMPACTS?

What does the Elephant Assessment (2008) say?

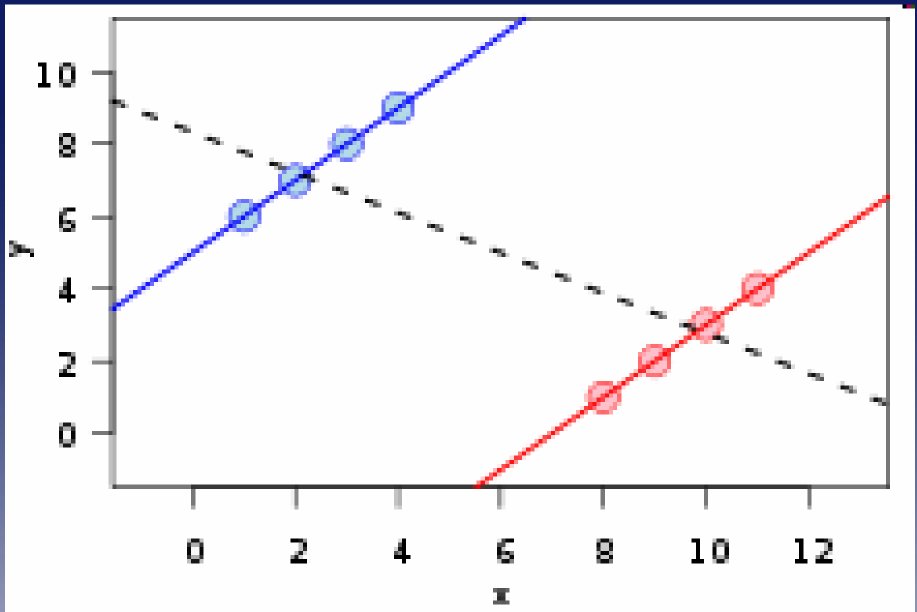
- Need to know consequences of high densities of elephants for biodiversity
- Need to know how elephant impacts affect compositional, structural & functional diversity

Other issues:

- Problems with using traditional statistics to understand complex systems (Levick 2008, Rogers 2008)
- Necessity for taking an explicitly multiscaled approach (Zermoglio et al 2004)
- How to synthesize the understanding gained from a range of elephant (impact) studies (Grant et al 2005; Gaylard, Pickett & Cadenasso *in review*)

Problems with traditional statistical techniques in complex systems:

Simpson's paradox & non-stationarity



a positive trend appears for two separate groups (blue and red), a negative trend (black, dashed) appears when the data are combined

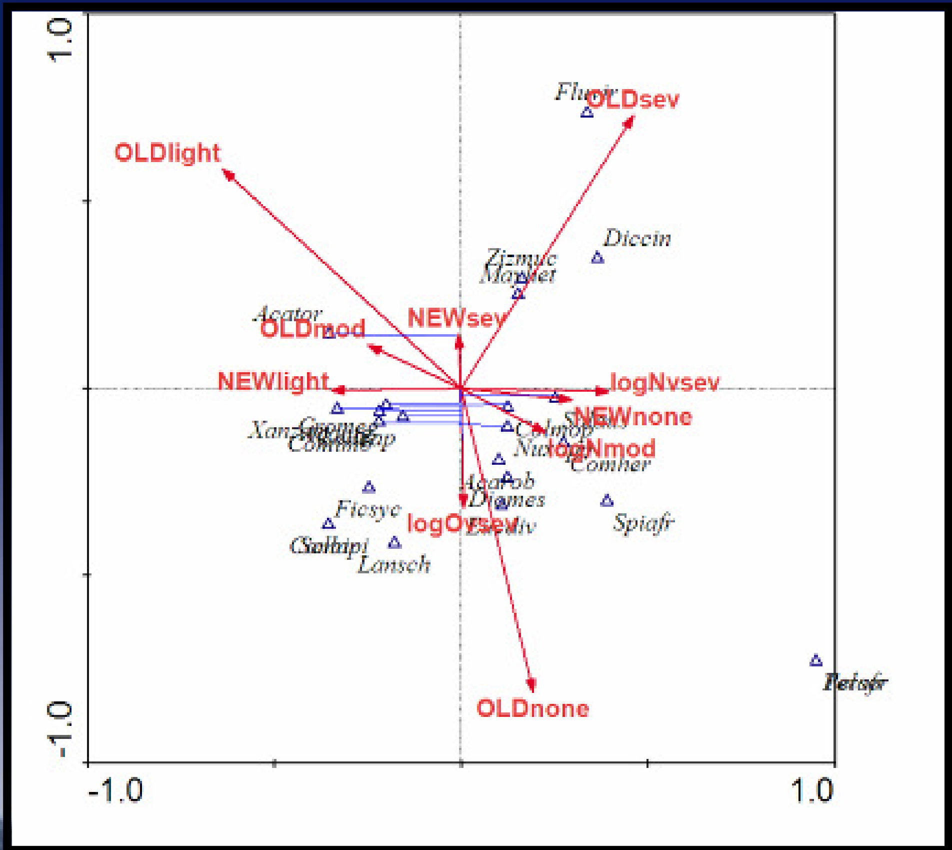
A stationary process/pattern is one whose probability distribution does not change when shifted in time or space & thus the mean & variance do not change in time or space

When (complex) systems suffer from Simpson's paradox due to non-stationarity, standard statistical tests cannot be used because they are based on calculating means & variances

Rogers 2008

A solution: multivariate statistics (CCA)

Traditional usage:



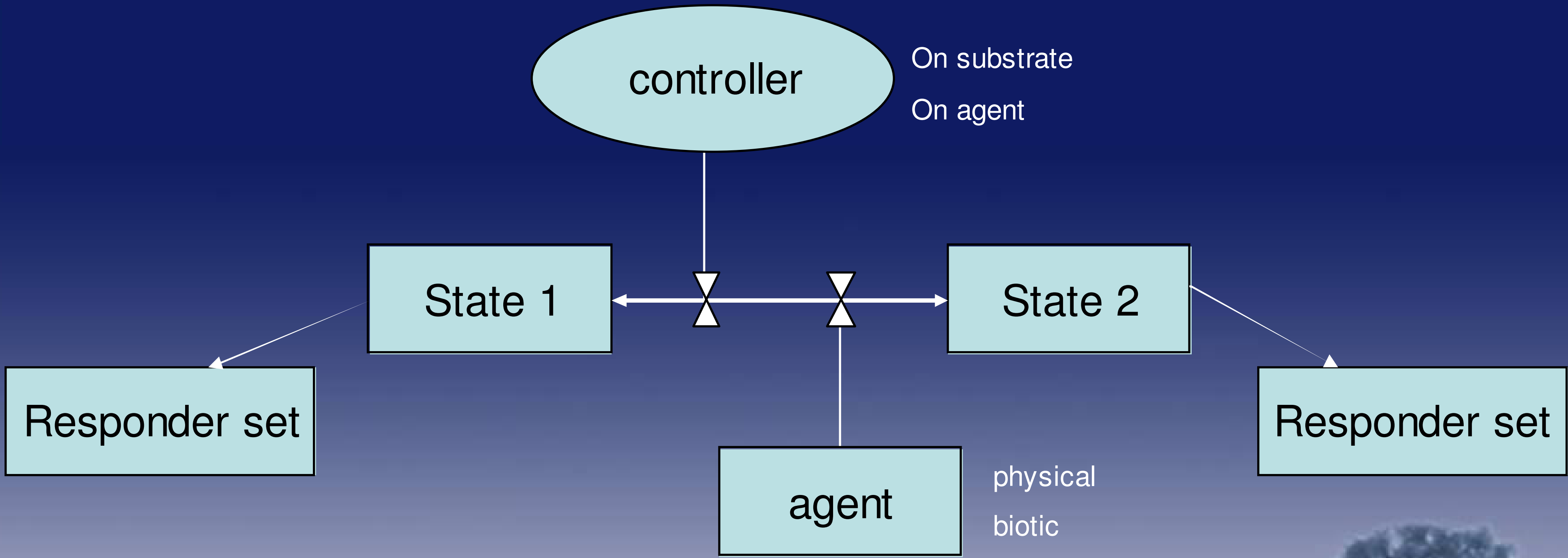
investigating factors that determine particular clusters of species/community composition

Provides a means to structure data by separating systematic variation from noise (Ter Braak & Verdonschot 1995)

More recent usage:

- Response variable = ecosystem response other than species composition: CCA with variation partitioning of the response variable with respect to environmental and spatial variables (Legendre 2007, Levick 2008)
- To address the problems of autocorrelation in natural systems (Legendre & Fortin 1989, Grand & Mellow 2004)
- For multiscale analyses of environmental relationships (Grand & Mellow 2004, Levick 2008)
- As a tool for hypothesis testing (McCune 1997)

Framework for understanding the generation of & responses to heterogeneity

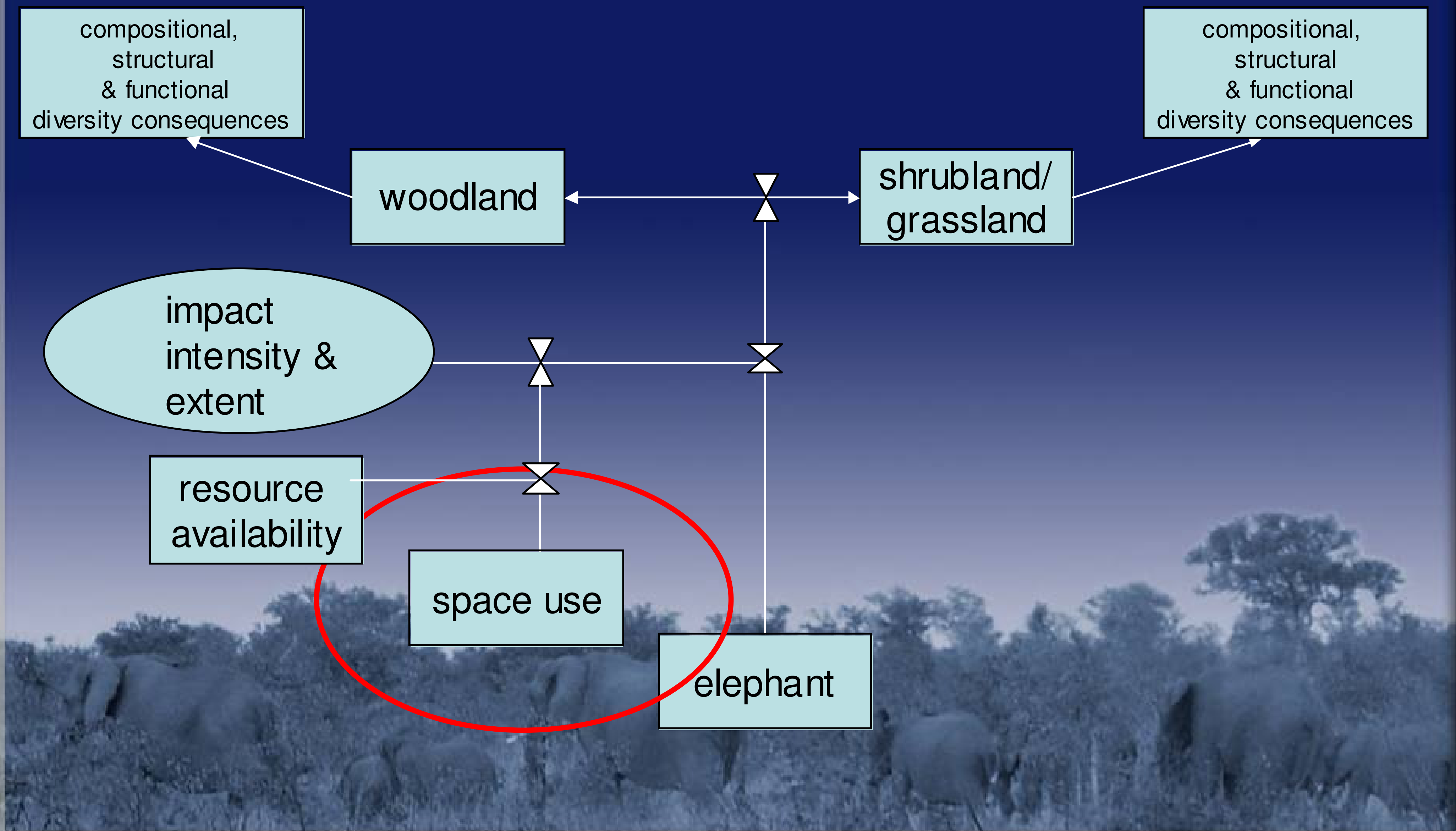


Pickett et al 2003

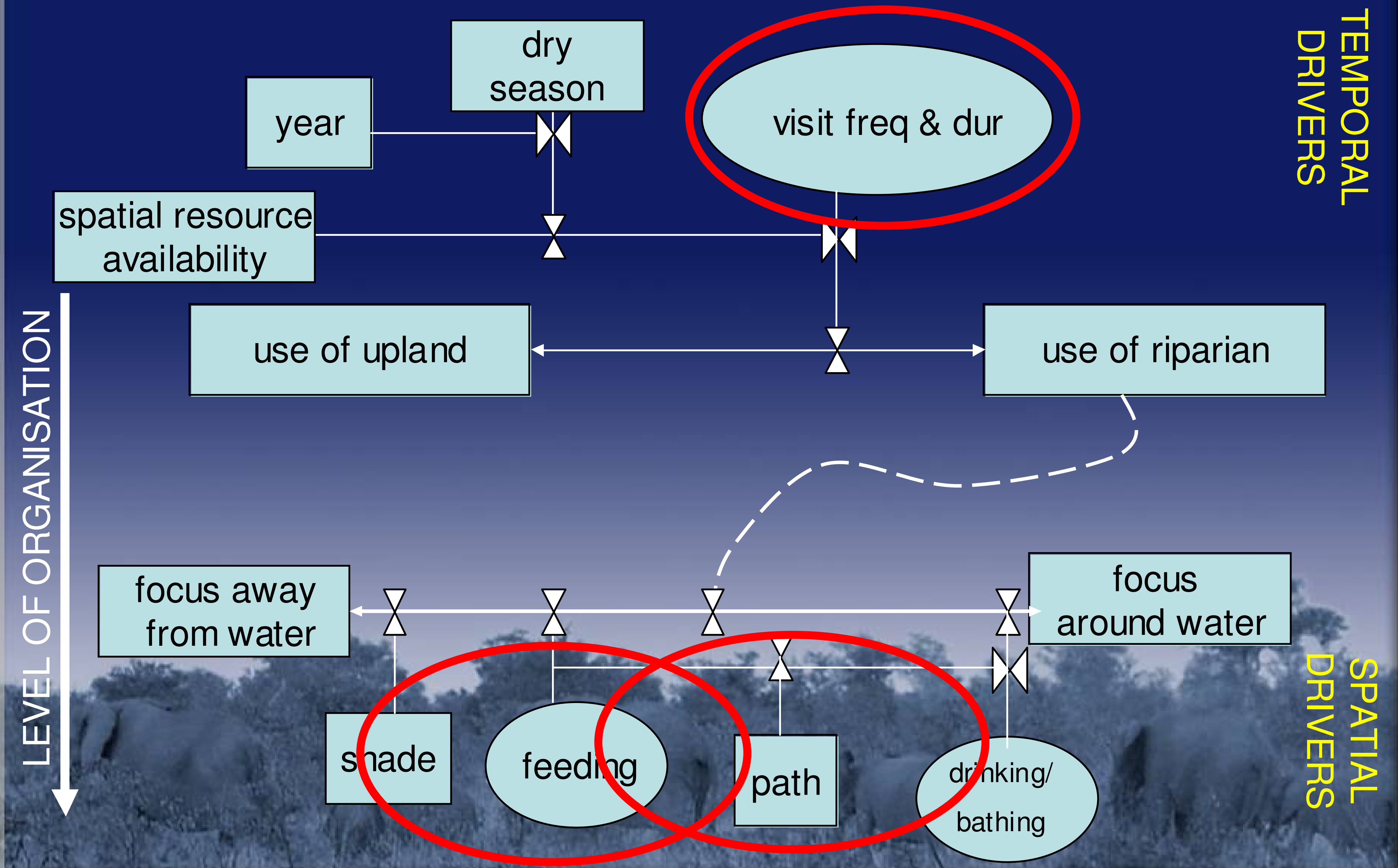
Pickett et al. (2003) framework

- forces us to link the patterns we see to the processes that create them, by using “state changes”, “drivers” and “responders”
- can be multiscaled & spatially explicit
- can be used as a knowledge management system by adding new info as it becomes available

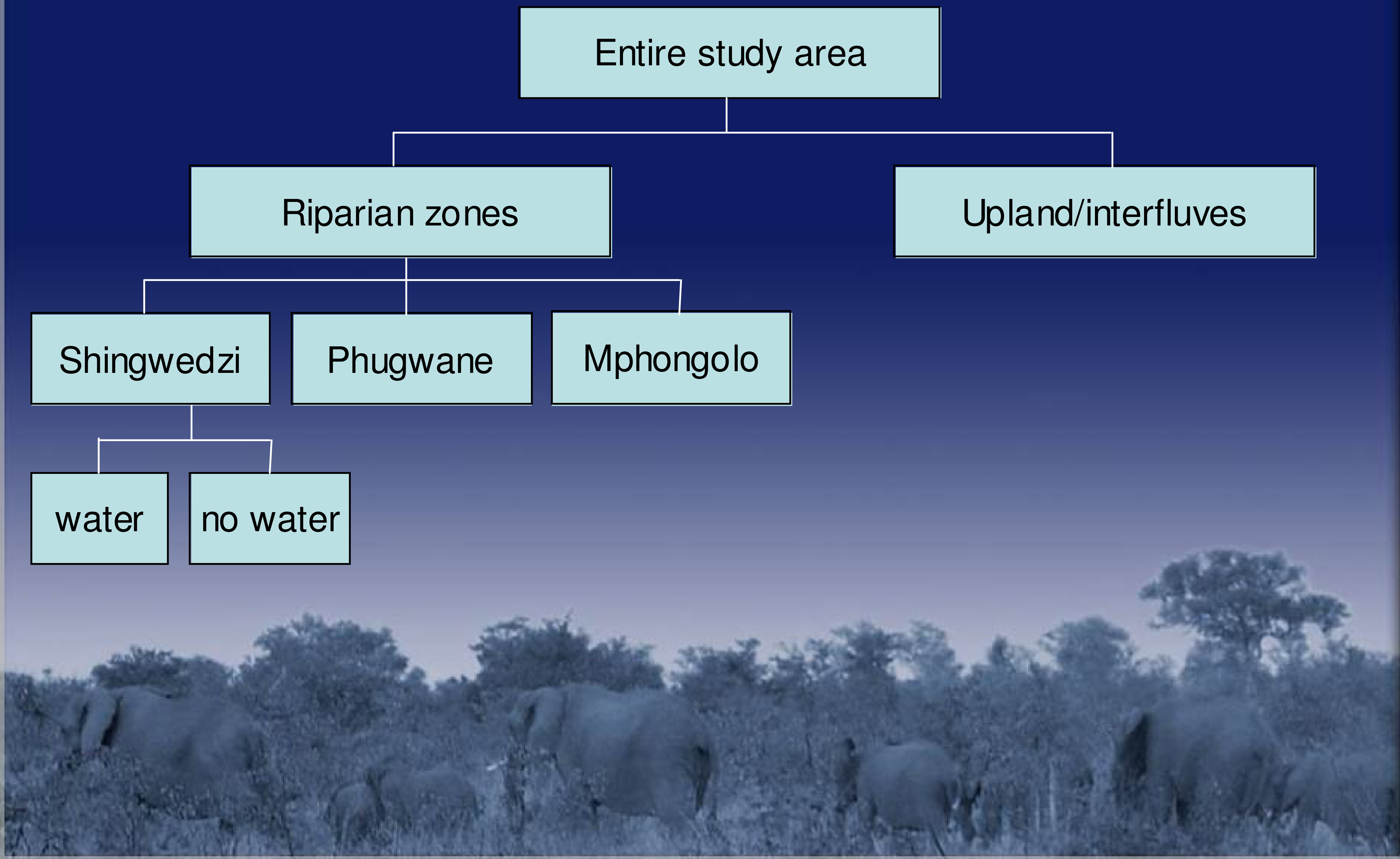
Conceptual model for understanding how elephants respond to & create heterogeneity



Using the framework to investigate spatial & temporal drivers of elephant space use



Multiple levels of organisation



Heat maps of CCA Results

TEMPORAL DRIVERS

SPATIAL DRIVERS

and >NB than spatial drivers for some space use

Temporal drivers >NB at some Levels

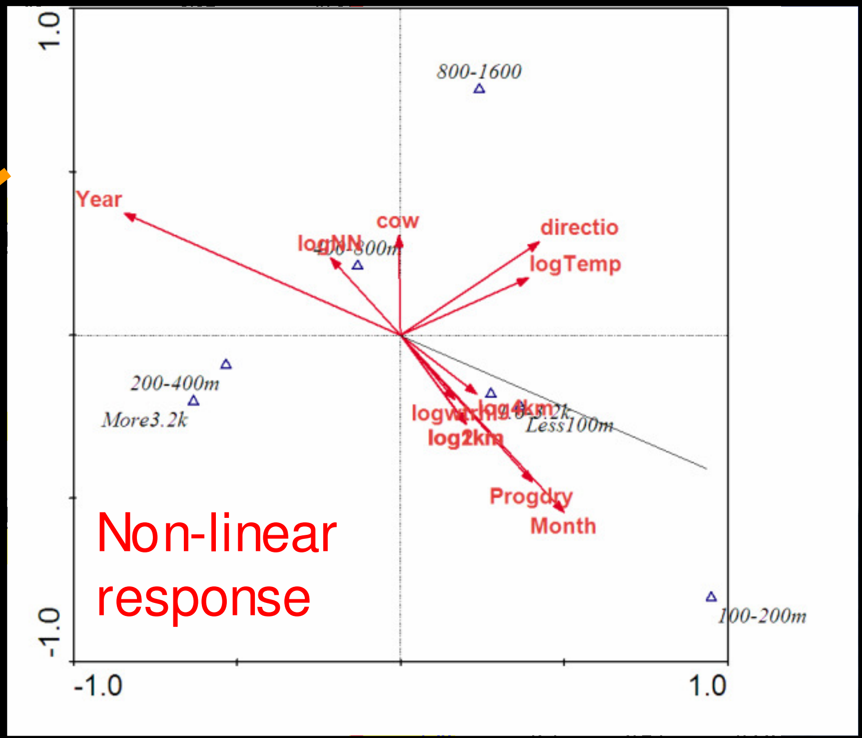
Frequency	Patch	F-values overallF	overall	month	year	progdry	temp	sex	Density of water within: 1km	2km	4km	8km	16km	waterhole proximity	abundance
Entire	Riparian	1.463	0.15	1.37	3.64	3.[illegible]3	1.6	1.28	1.47	0.27	0.47	0.94		0.4	0.99
Entire	Upland	1.260	0.25	0.73	3.64	3.2[illegible]	0.31	0.7	0.93	1.24	0.66	0.56		2.29	0.1
River system	Shingwedzi	0.693	0.84	2.38	0.84	2.5	0.29	0.6		0.11	0.24	0.8		0.11	0.05
River system	Phugwane														
River system	Mphongolo	0.964	[illegible].47	2.44	0.5	0.5	1.9	0.3	2.63		0.21			0.03	0.12
Inter-fluve	[illegible]zi	0.694	0.83	2.38	0.31	2.[illegible]5	0.3	0.67	1.25		0.19	0.55		0.3	0.2
Inter-fluve	[illegible]e														
Inter-fluve	[illegible]lo	0.850	0.57	2.44	0.22	0.27	1.9	0.37	0.31		2.91	0.21			0.3

[illegible]	Patch	overallF	overall	month	year	progdry	temp	sex	1km	2km	4km	8km	16km	proximity	abundance
[illegible]	[illegible]	1.245	0.19	0.88	1.59	1.56	0.91	1.84	0.69	0.08	1.88	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	1.233	0.21	1.28	1.66	1.67	0.44	0.86	0.48	1.71	1.26	[illegible]	[illegible]	[illegible]	[illegible]
River system	[illegible]zi	0.691	0.80	0.76	0.99	2.04	0.33	0.81	0.44			[illegible]	[illegible]	[illegible]	[illegible]
River system	Phugwane											[illegible]	[illegible]	[illegible]	[illegible]
River system	Mphongolo	1.756	0.12	1.87	0.01	1.14	1.61	1.2	2.09	4.65		[illegible]	[illegible]	[illegible]	[illegible]
Inter-fluve	Shingwedzi	0.691	0.80	0.81	0.27	2.04	1.71	1.07	0.15			[illegible]	[illegible]	[illegible]	[illegible]
Inter-fluve	Phugwane											[illegible]	[illegible]	[illegible]	[illegible]
Inter-fluve	Mphongolo	1.604	0.17	1.87	0.88	2.63	1.61	1.38	0.47	[illegible]	[illegible]56	[illegible]	[illegible]	[illegible]	[illegible]

Path	Patch	overallF	overall	month	year	progdry	temp	sex	1km	2km	4km
Entire	Riparian	2.295	0.00	1.74	4.71	2.6	1.55	5.45	2.4[illegible]	1.47	1.87
Entire	Upland	2.441	0.00	1.37	4.71	2.8	0.95	5.4[illegible]	2.57	1.99	2.16
River system	Shingwedzi	1.739	0.00	1.12	2.61	2.13	1.27	[illegible]		2.62	0.98
River system	Phugwane	1.529	0.02	1.8	1.52	1.11	0.9[illegible]	2.09	1.33	1.37	2.73
River system	Mphongolo	1.473	0.01	0.68	4.22	0.23	0.52	1.26	2.15		1.49
Inter-fluve	Shingwedzi	1.658	0.00	1.12	2.61	[illegible]13	1.27	3.85	1.08	0.92	1.51
Inter-fluve	Phugwane	1.589	0.01	2.47	1.45	1.4[illegible]	0.49	2.09	1.25		
Inter-fluve	Mphongolo	1.503	0.01	0.66	4.22	1.[illegible]8	1.01	1.26	0.61	2.61	

Feeding	Patch	overallF	overall	month	year	progdry	temp	sex	1km	2km	4km
Entire	Riparian	1.660	0.05	1.04	2.01	0.68	4.08	0.29		0.81	1.06
Entire	Upland	1.598	0.05	0.74	2.51	1.06	4.08	0.31	0.81	0.75	0.34
River system	Shingwedzi	0.892	0.59	0.96	0.1	0.67	3.51	2.57	1.54	0.43	0.68
River system	Phugwane	0.821	0.57	0.17	0.75	1.52	0.05	0.53			
River system	Mphongolo										
Inter-fluve	Shingwedzi	0.892	0.59	1.62	0.2	0.38	3.51	2.57	0.19		0.59
Inter-fluve	Phugwane	0.821	0.57	0.17	1.29	6.12	0.05	0.82			0.24
Inter-fluve	Mphongolo										

<<0.005



Non-linear response

Conclusions

- drivers & responders of elephant impact are too complex over different scales/levels of organisation to be adequately captured using traditional univariate statistical methods

- multivariate techniques are required to overcome "Simpson's paradox" & non-stationarity

- frameworks that explicitly incorporate drivers & responders help to integrate & synthesize our independent & collective understanding of the processes associated with the patterns (of elephant space use & impact) that we see

YES, WE STILL HAVE A LOT TO LEARN ABOUT ELEPHANT IMPACTS!

Acknowledgements:

Wits University, River/Savanna Boundaries Programme

SANParks

Andrew W. Mellon Foundation

Steward Pickett, Mary Cadenasso

Vilisoni Dinda