Where does the grassland stop and the forest begin?

Observatories for detecting biome shifts under global change

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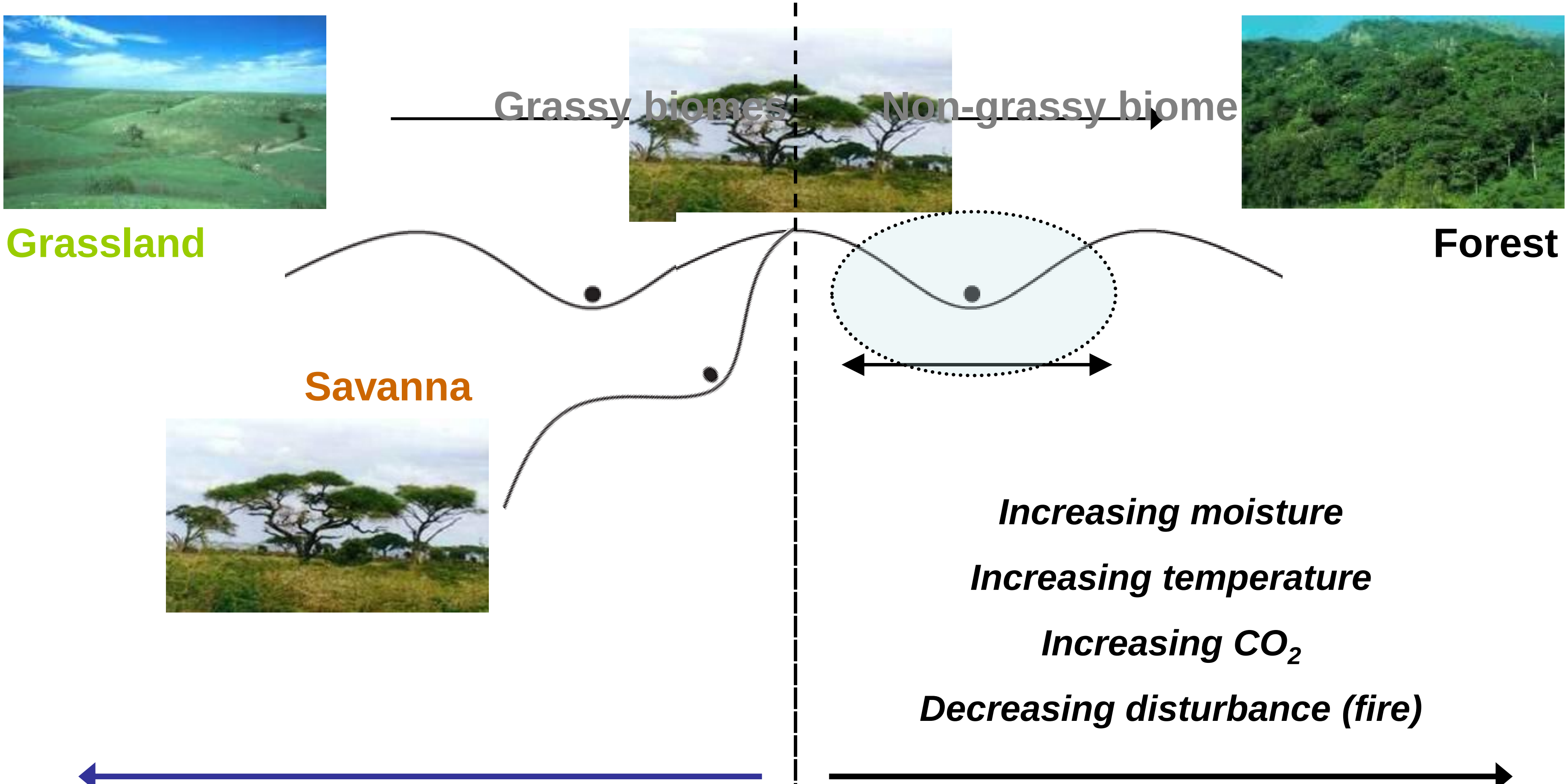
SAEON NDLOVU NODE

South African NATIONAL PARKS

NRF National Research Foundation

SAEON South African Environmental Observation Network

1. Understanding the (eco)System



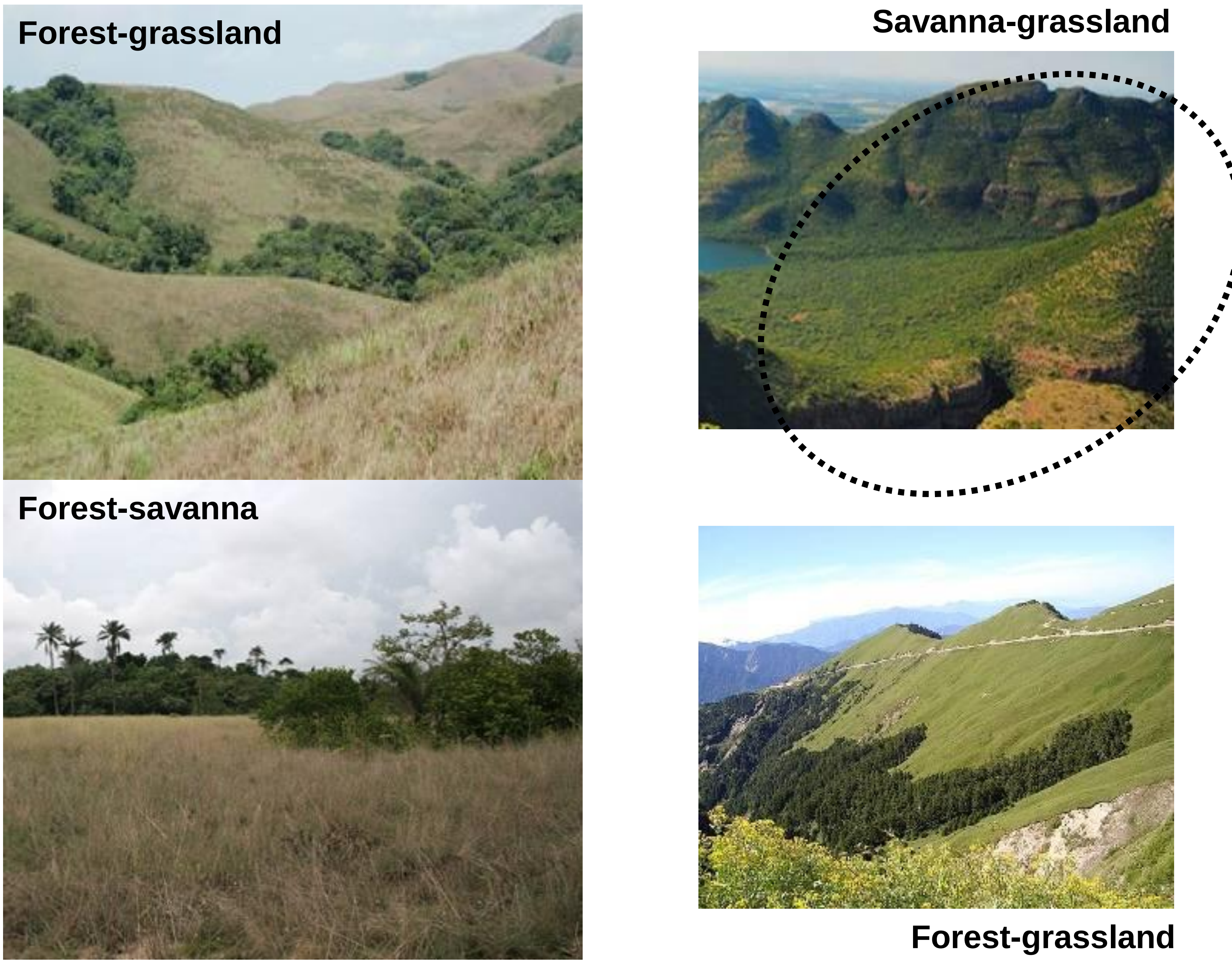
Decreasing moisture

Decreasing temperature

Decreasing CO_2

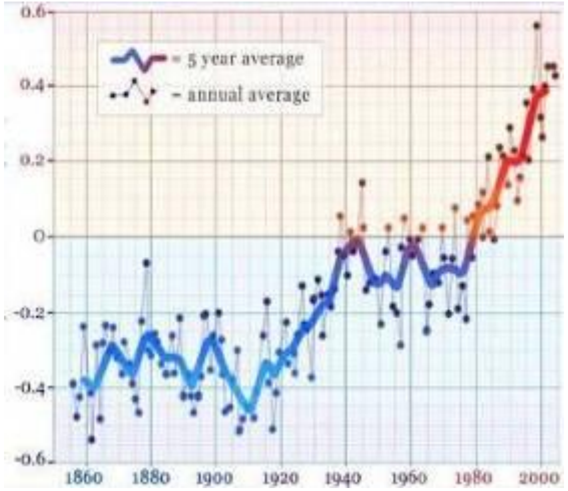
Increasing disturbance (fire)

- Typically abrupt (< 2m) boundaries
- Transition / Boundary shift relatively rapid cf. period of stability


Forest-grassland
Savanna-grassland
Forest-savanna
Forest-grassland

2. Understanding Global Change: Projections

RCM scenarios of doubled CO_2 by 2050 (*Davis, 2010*)



TEMPERATURE

Estimated 2-3°C increase for southern Africa, 5°C by 2100

Max temp, mean temp ^ **Min temp** ^^

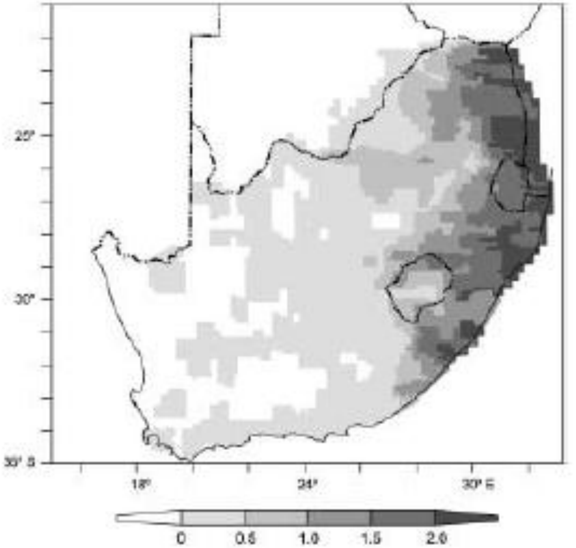
[*Spring, at altitude*]

RAINFALL

Annual, monthly, aseasonal, evaporation, rain events ^^

Dry days vv **Dry-spell duration** —

[*At altitude*]



ATMOSPHERIC CO_2

Global CO_2 loading ^^

[*Ubiquitous*]

3. Predictions & Consequences

Grassland → Savanna → Forest

Grassland → Forest

Increasing moisture

Increasing temperature

Increasing CO_2

Fire?

Prevent & Revert

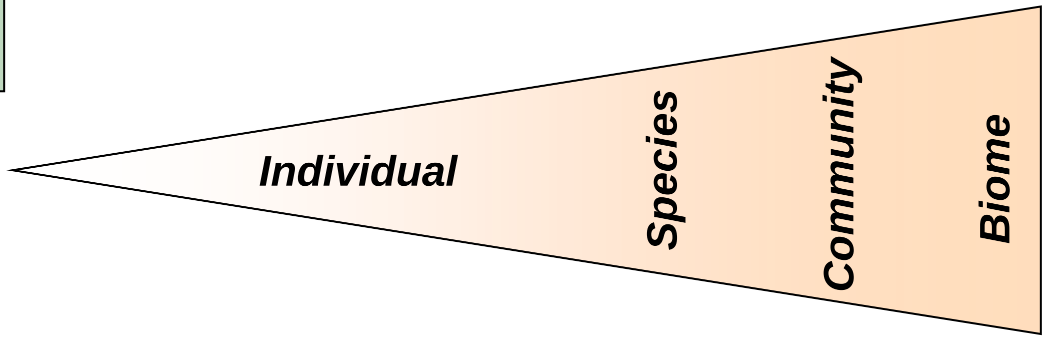
Land-use, management, CO_2 loading, climate

- **Increased photosynthetic capacity**
- **C3 / C4 advantage**
- **Increased water-use efficiency**
- **Accelerated growth**
- **Extended / Uninterrupted growth**
- **Increased germination / recruitment**

Physiological

- **Relative survival capacity**
- **Shift in competitive balance**

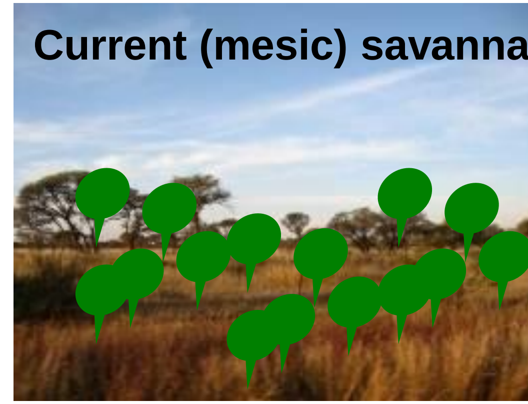
- **Favour survival of C-rich growth forms [*1º & re-growth*]**



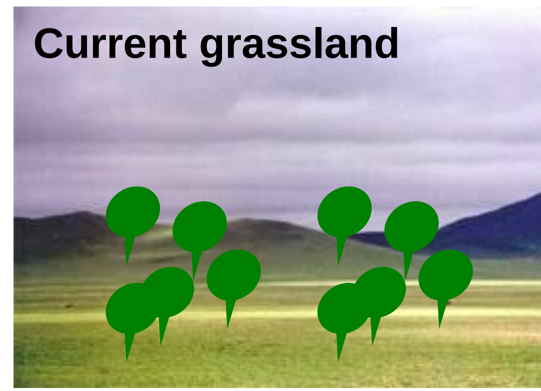
Mode of Action

4. Predictions: Species to Biomes

***Species* – major rearrangement (extirpation, invasion)**
***Community* – shift in structural & functional diversity (thickening to closed canopy woodland)**
***Biome* – local biome loss (to alternative state / forest)**

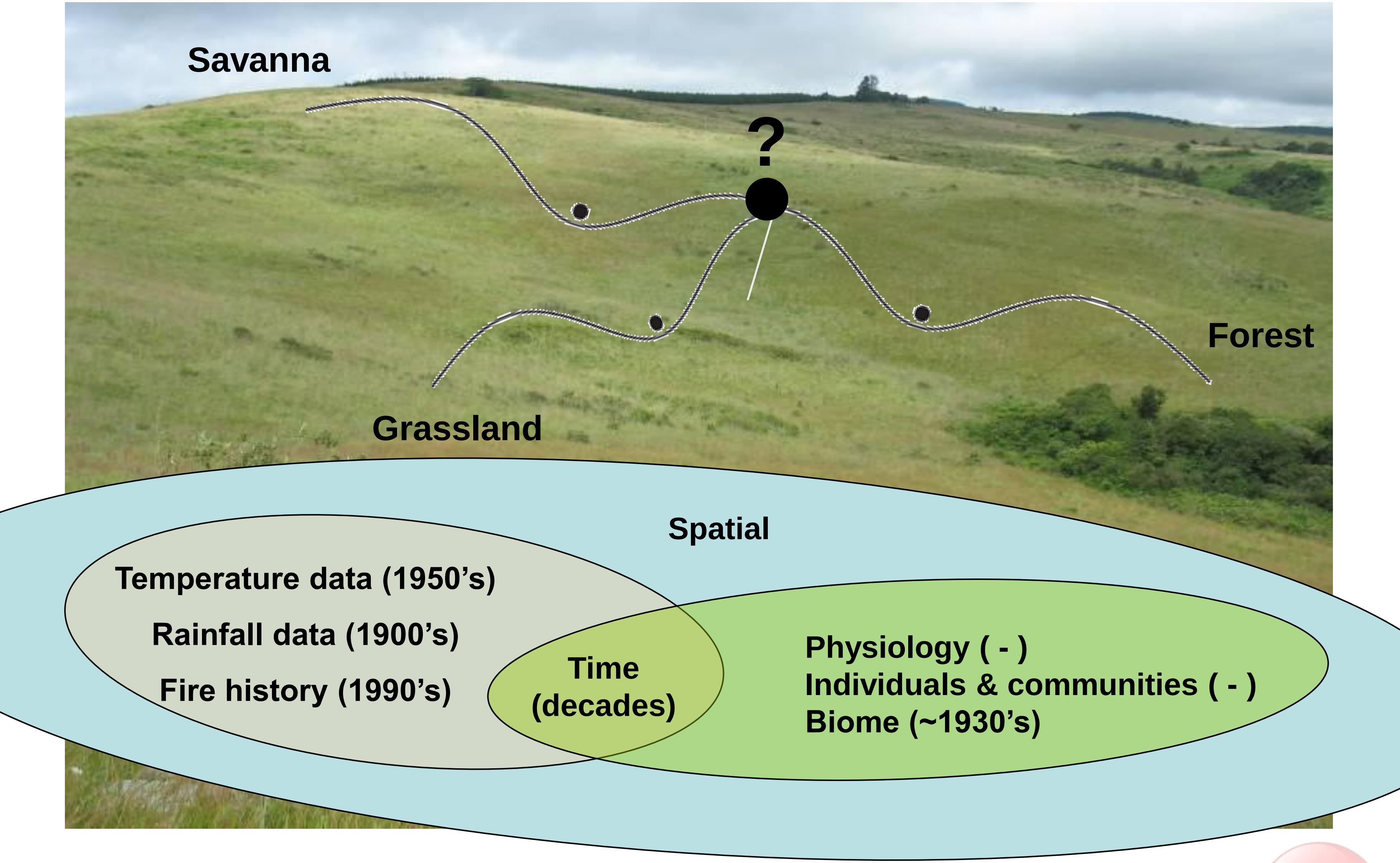


Species – major rearrangement (extirpation, invasion)
***Community* – shift in structural & functional diversity (tree ingress)**
***Biome* – regional biome loss (shift to savanna / forest)**



***Species* – minor rearrangement (extirpation)**
***Community* – ?**
***Biome* – regional expansion into grassland biome**

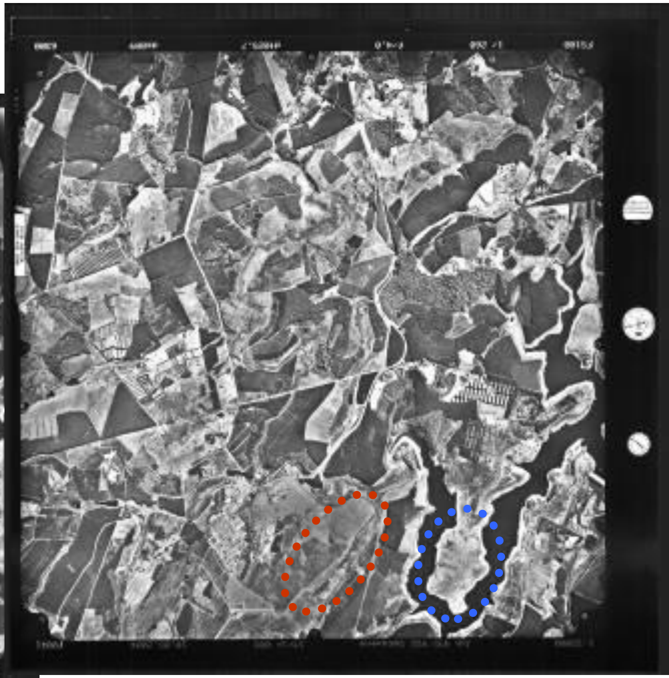
Climatic drivers act along gradients (altitude & latitude)
Responses likely abrupt (alternative stable state)



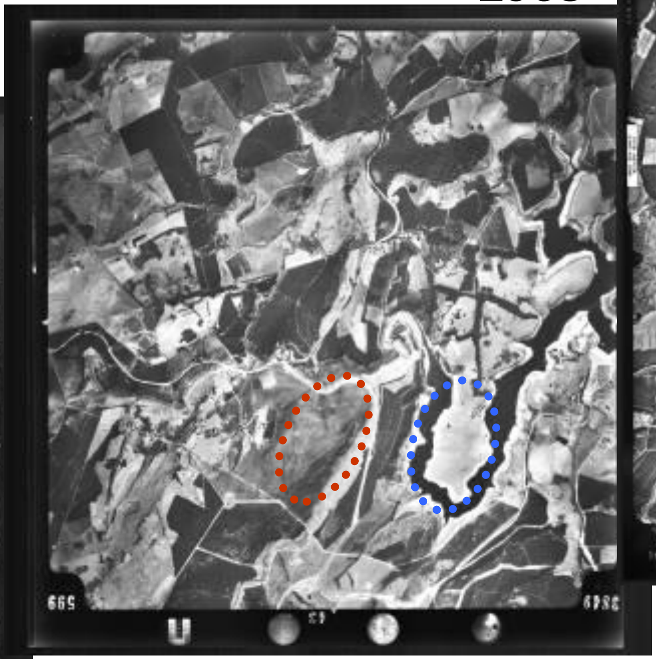
Abundant theory, limited driver data, and non-existent, complementary site-based evidence / monitoring of the biological response

5. Few answers…

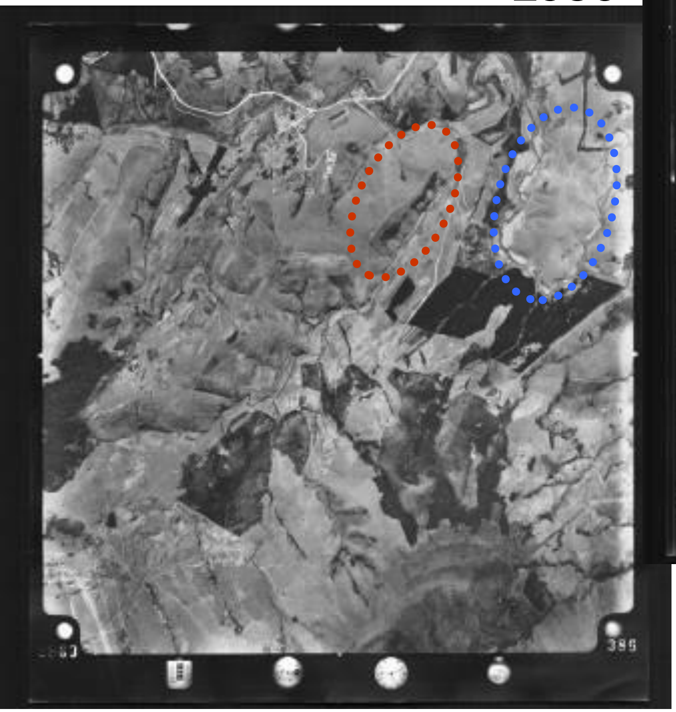
2004



1968



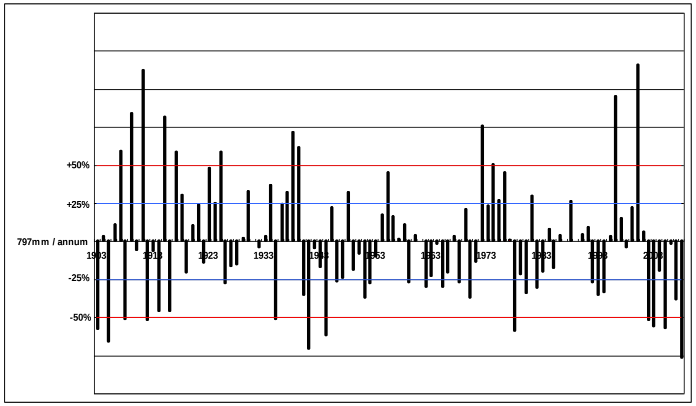
1956



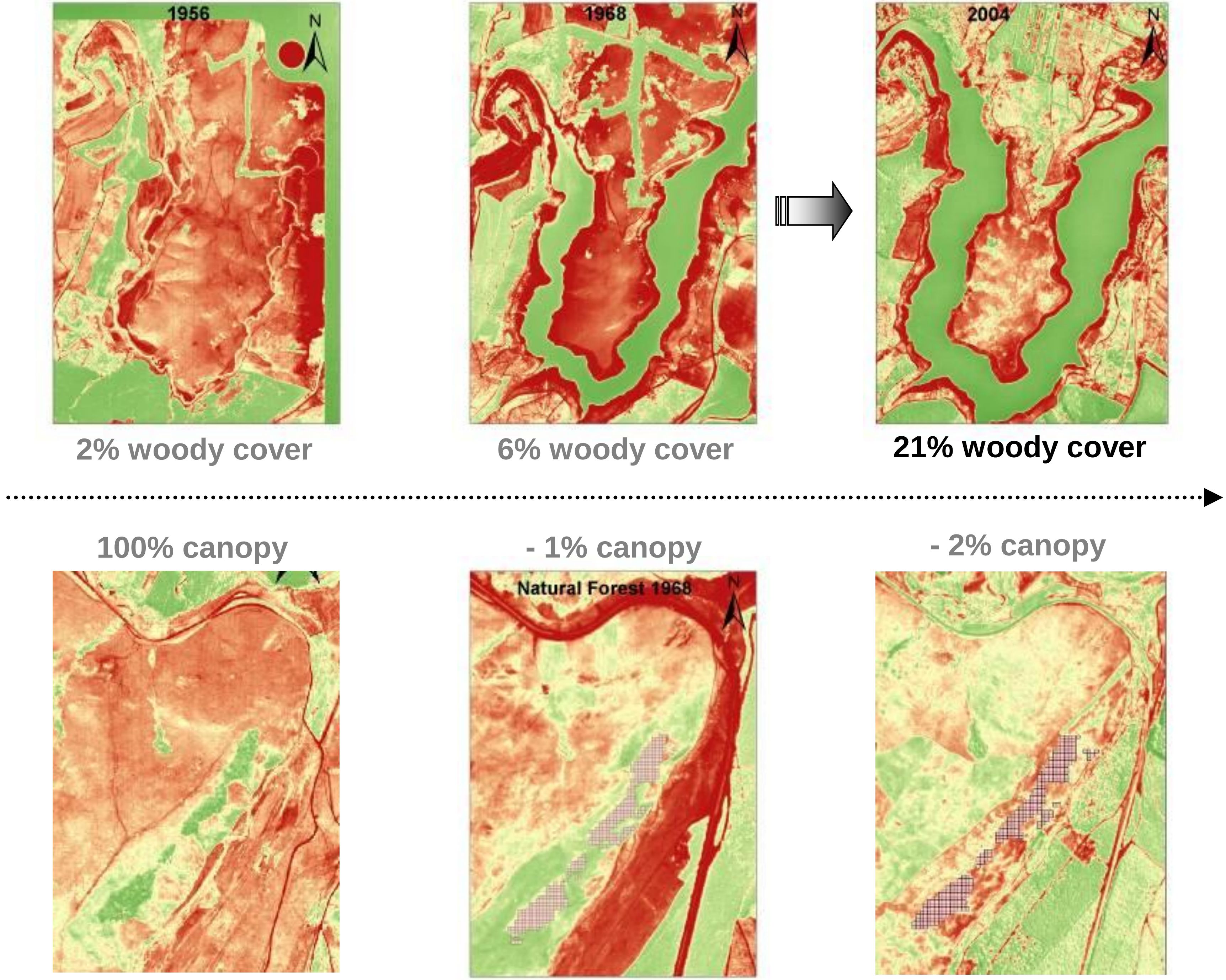
1986
Temperature

1990's
Fire history

1903
Rainfall



?


1956
N
1968
N
2004
N
2% woody cover
6% woody cover
21% woody cover
100% canopy
- 1% canopy
- 2% canopy
Natural Forest 1968
N

6. …many questions

1. What are the drivers, and the critical thresholds thereof, of the biomes in Limpopo

1.1 What mechanisms determine the ingress of grasslands by woody species at local and regional scales? (particularly the interactions between rainfall, temp & fire)

1.2 What mechanisms prevent the invasion of grassy biomes (grassland and savanna) by forest species? (particularly the interaction between micro-climate & fire)

1.3 Will the effect of fire in preventing woody plant establishment diminish under future, predicted climates?

2. At which scale, and at what rate (current and future), are the biomes of Limpopo responding to global change

2.1 Is there evidence of recent / current movement of the forest-grassland / forest-savanna boundary at the regional scale?

2.2 What is the rate of expansion of mesic savanna and forest into adjacent grasslands?

- **Dedicated, question-driven, site-based, long-term, coordinated research / monitoring efforts**
- **Driver and response data**
- **Simple, rigorous and repeatable design**
- **Multiple scales**

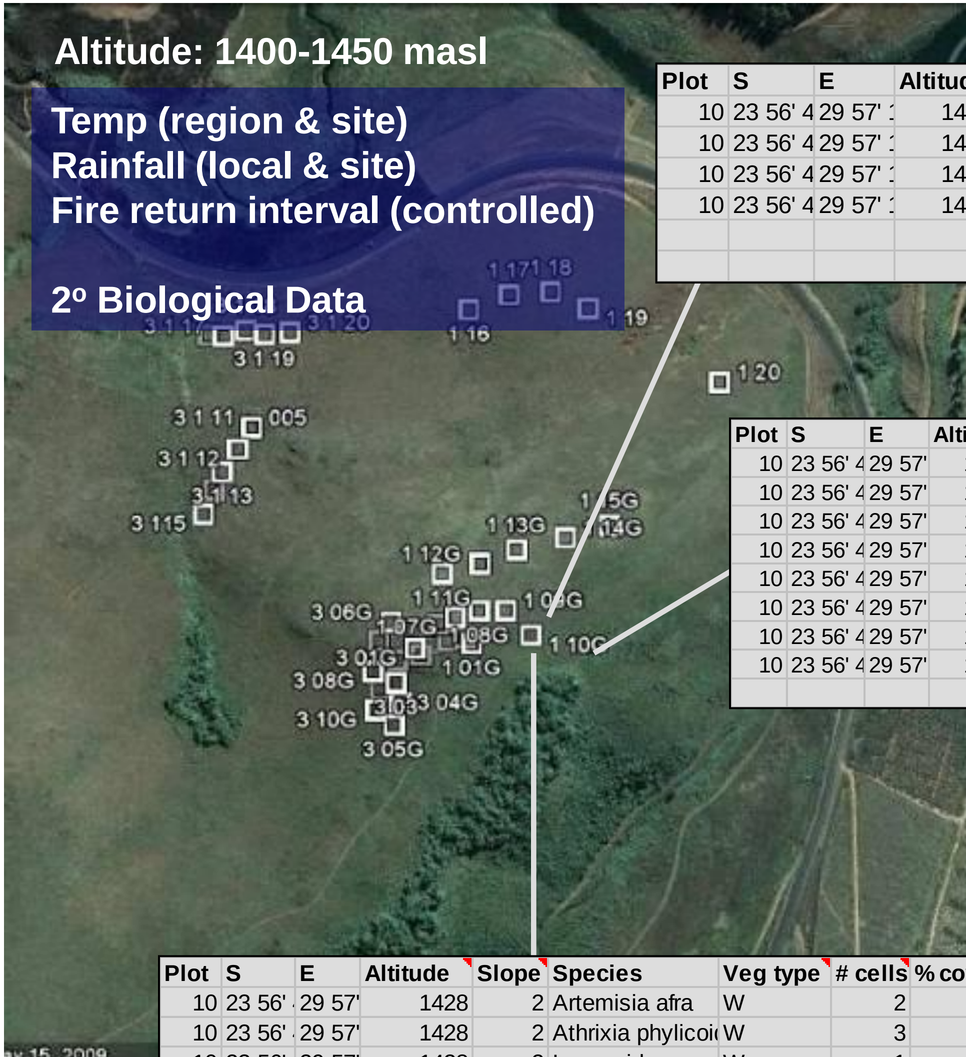
Biodiversity Observatories (~ LTER model)

- **Appropriate biomes (*grassland, savanna & forest*)**
- **Driver gradients / manipulation (*management / land-use, altitude & latitude*)**

North-eastern Escarpment

7. Haenertsburg Observatory (+ *fire; - climate*)

Woodbush granite grassland (endangered), Mamabolo mountain bushveld & Northern mistbelt forest (Mucina *et al*., 2008) in Limpopo uKhahlamba-Drakensberg foothills



Plot	S	E	Altitude	Slope	Subplot	Species	Veg	% cover 2009	Reproductive 2009
10	23 56' 4	29 57' 1	1428	2	D	Cymbopogon excav	G	10	R
10	23 56' 4	29 57' 1	1428	2	D	Cymbopogon validu	G	60	R
10	23 56' 4	29 57' 1	1428	2	D	Hyparrhenia tamba	G	25	R
10	23 56' 4	29 57' 1	1428	2	D	Sedge	G	1	N
							4	*96*	*Cumulative*
								0	*Bare*

240 nested 1x1m permanent plots across annually and triennially burned grassland

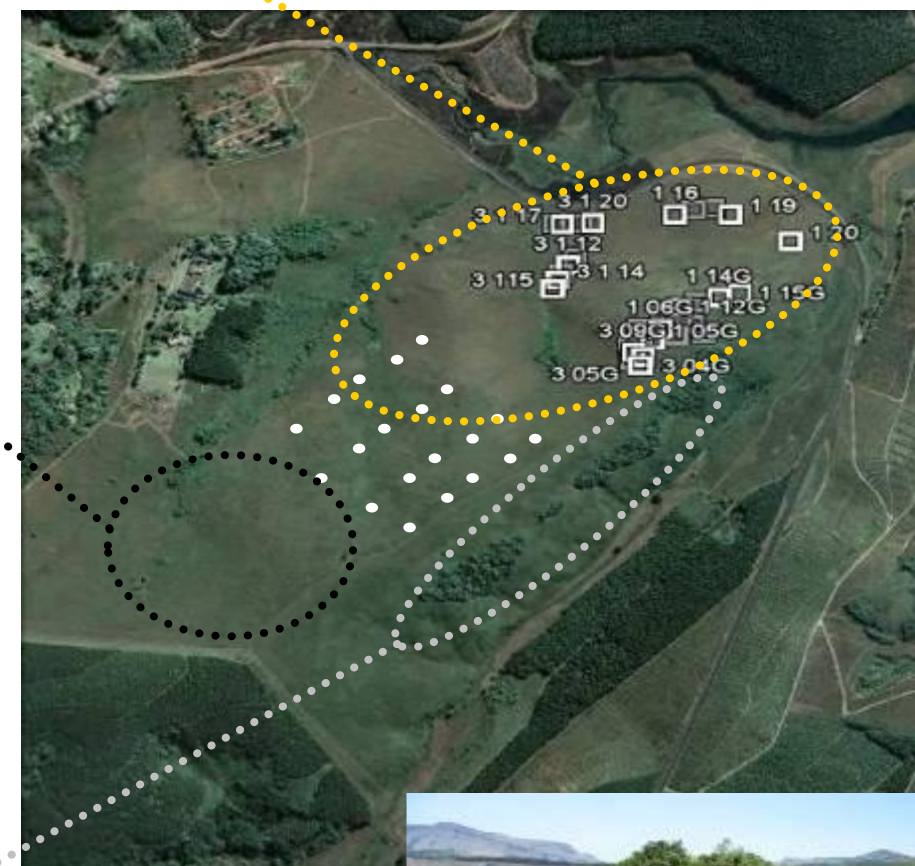
Plot	S	E	Altitude	Slope	Subplot	Species	Veg	% cover 2009	Reproductive 2009
10	23 56' 4	29 57'	1428	2	B	Acalypha peduncularis	F	7	N
10	23 56' 4	29 57'	1428	2	B	Berkheya setifera	F	6	N
10	23 56' 4	29 57'	1428	2	B	Geranium wakkerstroom	F	3	N
10	23 56' 4	29 57'	1428	2	B	Helichrysum nudifolium	F	14	N
10	23 56' 4	29 57'	1428	2	B	Hirpicium bechuanense	F	5	N
10	23 56' 4	29 57'	1428	2	B	Monopsis decipiens	F	1	N
10	23 56' 4	29 57'	1428	2	B	Rhoicissus tridentata	F	8	N
10	23 56' 4	29 57'	1428	2	B	Tragia rupestris	F	1	N
							8	*45*	*Cumulative*

60 4x4m permanent plots across annually and triennially burned grassland

Plot	S	E	Altitude	Slope	Species	Veg type	# cells	% cover 2009	Reproductive 2009	max. heig	no. of stem	max stem	Resprout
10	23 56' .	29 57'	1428	2	Artemisia afra	W	2	1.63	R	142	20	<1	Y
10	23 56' .	29 57'	1428	2	Athrixia phylicoi	W	3	0.75	N	72	10	<1	N
10	23 56' .	29 57'	1428	2	Leucosidea	W	1	0.31	J	86	2	<1	N
10	23 56' .	29 57'	1428	2	Rhus pyridoides	W	1	1.25	N	154	5	<1	Y
						4		*3.94*	*Combined woody cover*		*37*		

Population census of persistent geophytes
- **Functional ages (J, NR, R, D) & phenologies**
- **Reproductive effort & success**

Population census of *A. sieberiana*
- **Functional ages (J, NR, R, D)**
- **Phenologies**
- **Reproductive effort & success**



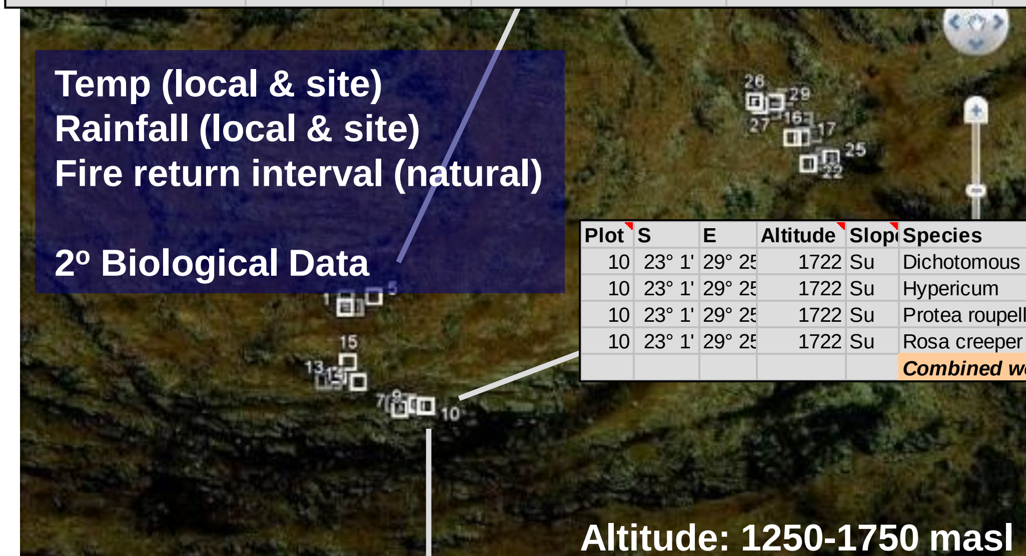
Forest-grassland boundary
- **Distance from permanent marker**
- **Remote imagery**
- **Training exercise in regional analysis**

Fire

8. Lajuma Observatory (- *fire; + climate*)

Soutpansberg sourveld, Soutpansberg mountain bushveld, Makhado sweet bushveld & Northern mistbelt forest (Mucina *et al*., 2008) in Western Soutpansberg, Limpopo

Plot	S	E	Altitude	Slope position	Subplot	Species	Veg type	% cover 2009	Reproductive 2009
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Asparagus laricinus	F	2	N
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Gerbera ambigua	F	5	R
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Indigofera sp.	F	1	N
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Stachys aethiopicum	F	1	N
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Ursinia nana	F	2	R
5	23° 1' 26.8"	29° 25' 44.8"	1736	Su	A	Vernonia oligocephala	F	6	N
							6	*17*	*Cumulaitve*

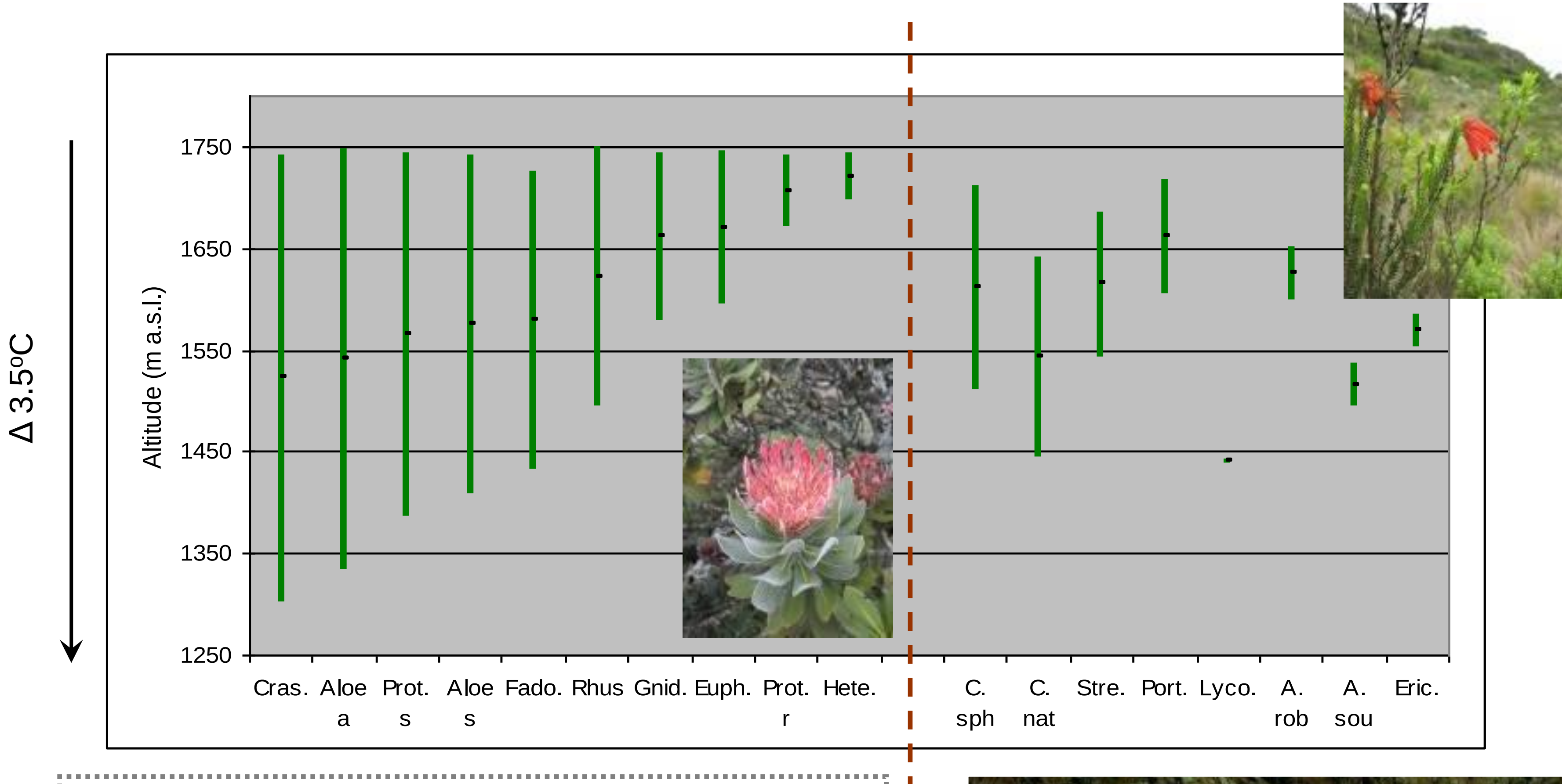


120 nested 1x1m permanent plots across an altitudinal gradient

Plot	S	E	Altitude	Slop	Species	Veg type	# cells	% cover 2	roductive	max. heigh	no. of stem	diameter	Resprout
10	23° 1'	29° 25	1722	Su	Dichotomous da	W	4	5.06	M	84	33	<1	Y
10	23° 1'	29° 25	1722	Su	Hypericum	W	5	5.25	M	105	16	<1	Y
10	23° 1'	29° 25	1722	Su	Protea roupelliae	W	3	5.9	M	105	17	4.3	Y
10	23° 1'	29° 25	1722	Su	Rosa creeper	W	9	3.38	M	21	30	<1	Y
					Combined woo		4	*19.59*		*78.75*	*96*		

Plot	S	E	Altitude	Slope	Subplot	Species	Veg type	% cover 2009	Reproductiv
10	23° 1' :	29° 25'	1722	Su	A	Cymbopogon excava	G	10	R
10	23° 1' :	29° 25'	1722	Su	A	Diheteropogon ample	G	40	R
10	23° 1' :	29° 25'	1722	Su	A	Hyparrhenia sp.	G	18	N
10	23° 1' :	29° 25'	1722	Su	A	Loudetia simplex	G	33	N
10	23° 1' :	29° 25'	1722	Su	A	Sedge	G	4	N
							6	*105*	*Cumulative*
								0	*Bare*

30 4x4m permanent plots across an altitudinal gradient

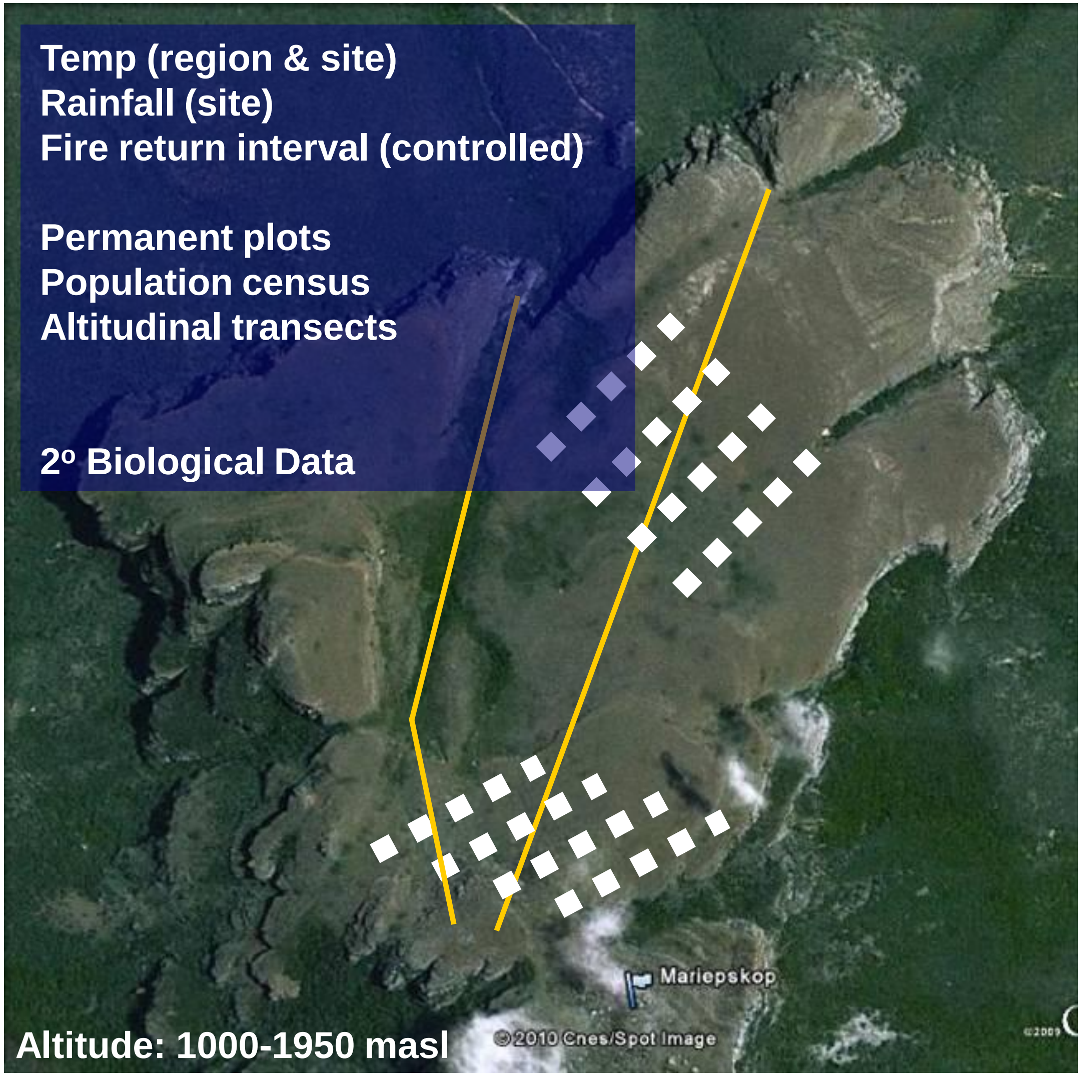


- **Altitudinal limits (min; max)**
- **Population census for representative taxa**
- **Functional ages (J, NR, R, D)**
- **Phenologies**
- **Reproductive effort & success**
- **Functional & structural traits**

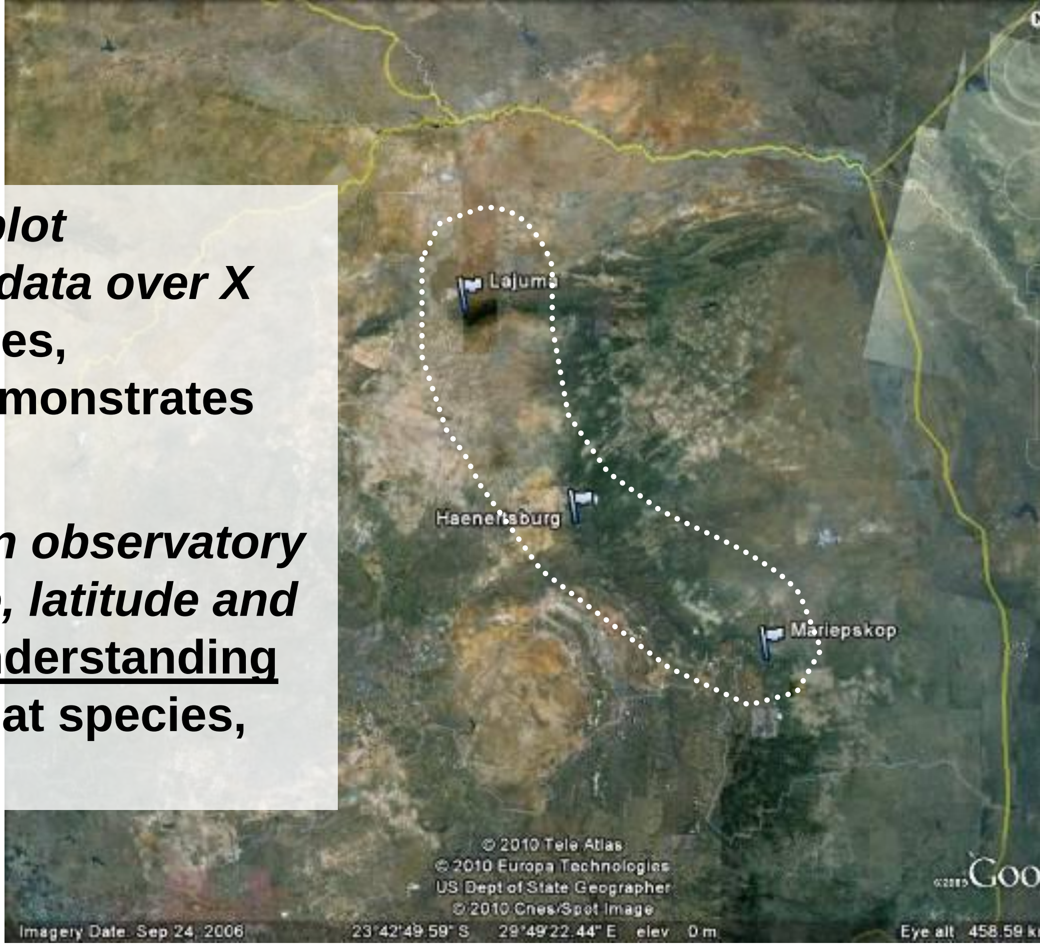
Temperature

9. Mariepskop Observatory (+ *fire; + climate*)

Northern escarpment quartzite sourveld, Northern escapement dolomite grassland, Legogote bushveld, Ohrigstad mountain bushveld, Northern mistbelt forest, Northern escarpment afromontane fynbos (Mucina *et al*., 2008) in Mpumalanga uKhahlamba-Drakensberg



10. Conclusion



1. ***Within observatory and within plot comparisons to these baseline data over X yrs*** **= Change <u>detection</u> at species, community and biome level. Demonstrates the pattern / nature of change.**
2. ***Within observatory and between observatory comparisons over time, altitude, latitude and land management practice*** **= <u>Understanding</u> the process / drivers of change at species, community and biome level**

Invite sharing of relevant data sets (conceptual)

Encourage use and expansion of the observatory network (physical)

Promote additive research and collaboration at observatory sites