

Long-term effects of fire on semi-arid savanna communities: Results from the EBPs

Melinda D. Smith
Yale University



Collaborators

Glynn Alard

Sandy Andelman (NCEAS, Conservation International)

Catherine Burns (Yale University)

Harry Biggs

Andres Brönn

Sarah Emery (Michigan State University)

Beukes W. Enslin

Navashni Govender

Judith Kruger

Andre L. F. Potgieter

Sean O'Regan

Dibba Rikhotso

Richard Sowry

Winston S. W. Trollope

Brian W. van Wilgen



Drivers of savanna community structure



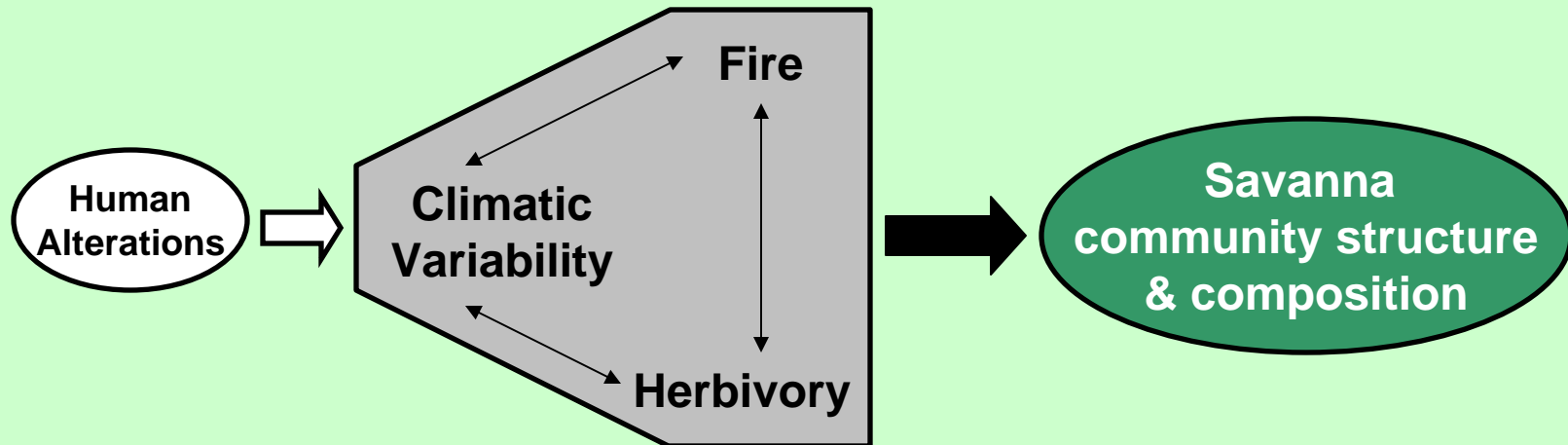
Climatic variability



Fire



Herbivory



Fire and savanna community structure



Elements of
the fire regime

Fire frequency
Fire intensity

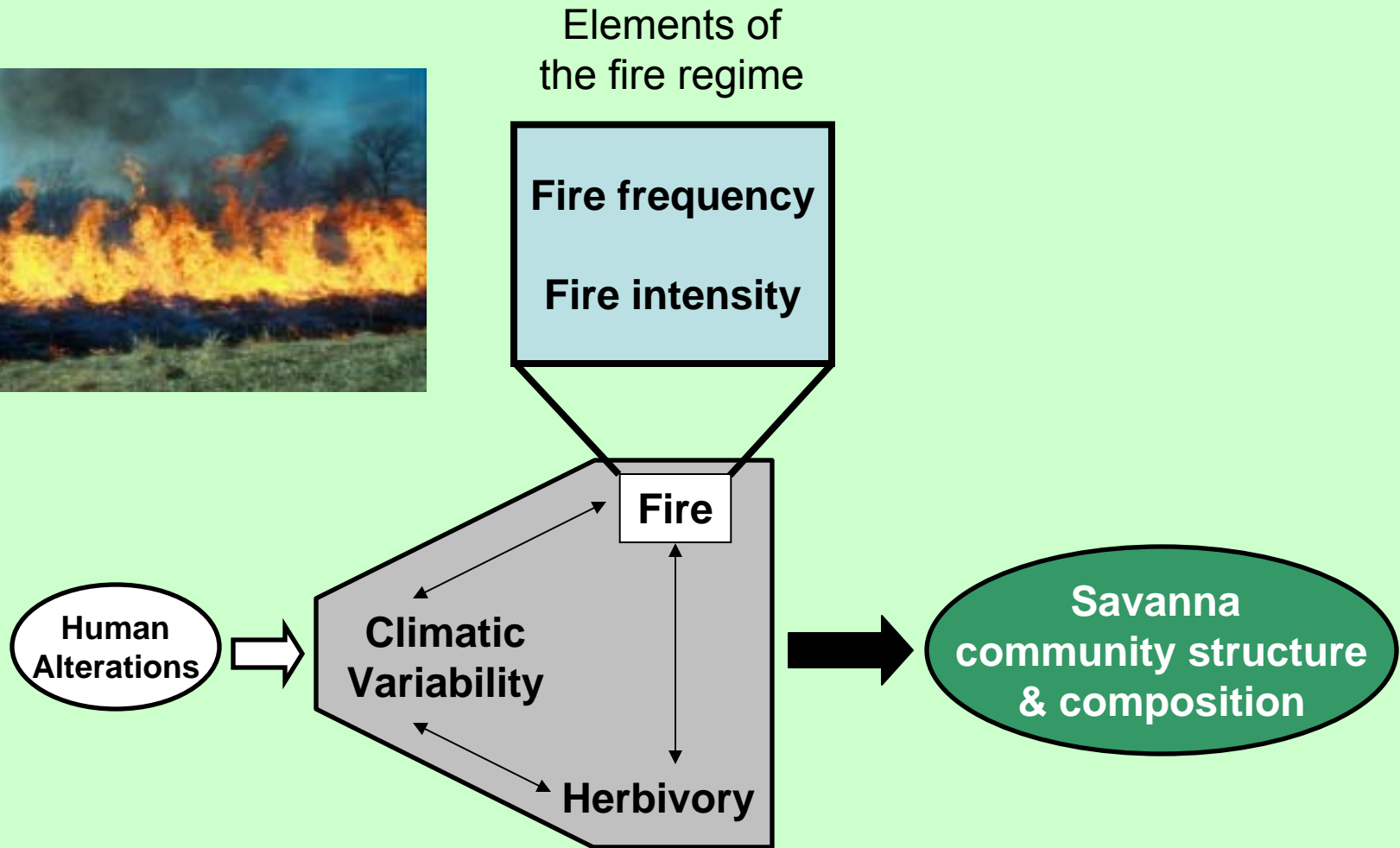
Human
Alterations

Climatic
Variability

Herbivory

Fire

Savanna
community structure
& composition



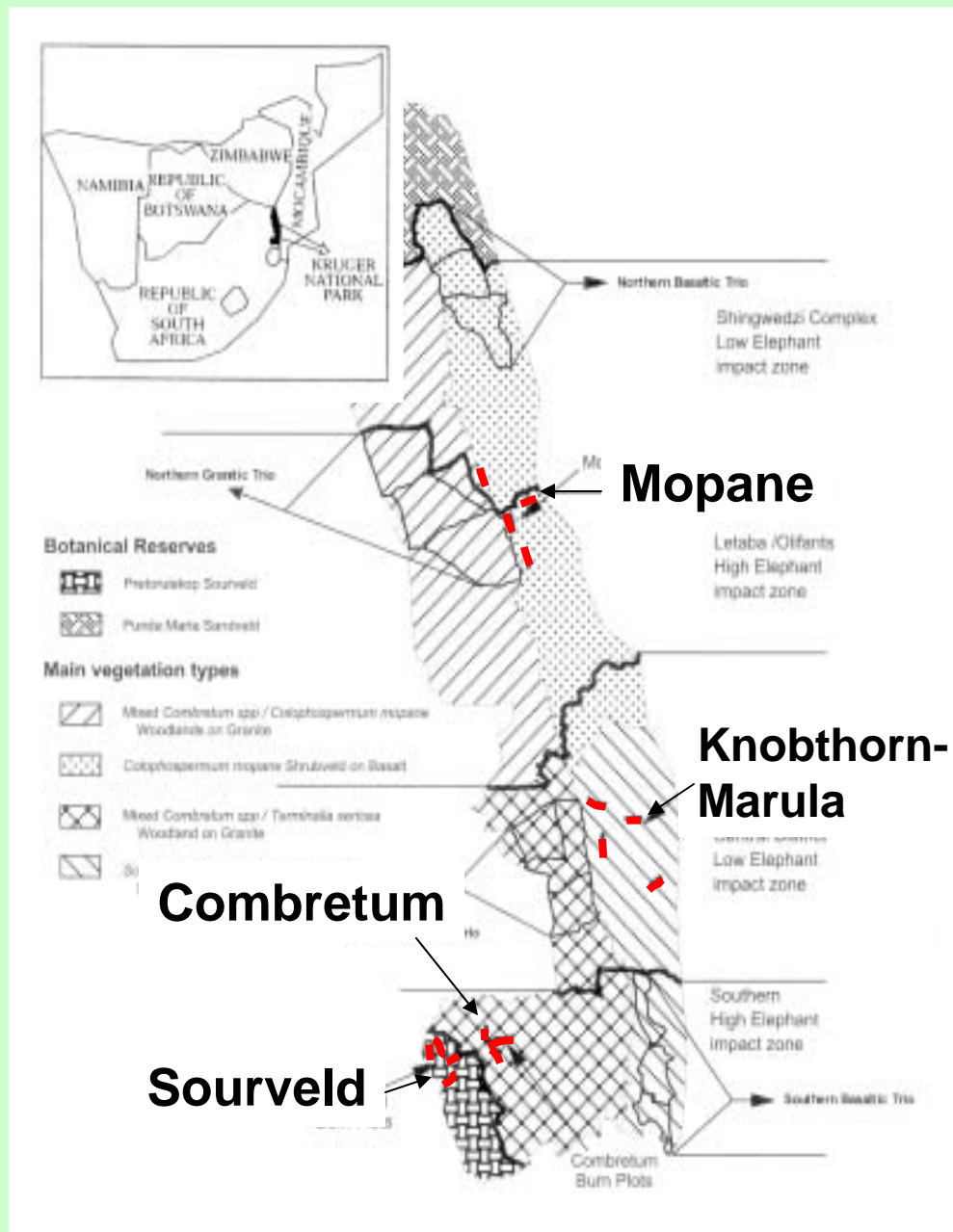
Experimental Burn Plots (EBPs)

Established in 1954 in four major vegetation types

4 blocks/site – 12 plots/block

N = 192 plots

Each plot ~ 7ha



Experimental Burn Plots (EBPs)

Study site/ Vegetation type	Dominant grass species	Soil type	Precipitation	
			mean (mm)	CV (%)
Sourveld	<i>Hyperthelia dissoluta</i> , <i>Panicum maximum</i> , <i>Setaria sphacelata</i>	Granite	705.5	39.4
Combretum	<i>Digitaria eriantha</i> , <i>Eragrostis rigidior</i> , <i>P. maximum</i>	Granite	572.3	35.4
Knobthorn- Marula	<i>Bothriochloa radicans</i> , <i>P. coloratum</i> , <i>D. eriantha</i>	Basalt	507.9	39.0
Mopane	<i>Enneapogon cenchroides</i> , <i>Urochloa mosambicensis</i> , <i>B. radicans</i>	Basalt	451.9	55.0

Experimental Burn Plots (EBPs)

Fire frequency/season treatments:

1-yr	Aug
2-yr	Aug, Oct, Dec, Feb, Apr
3-yr	Aug, Oct, Dec, Feb, Apr
Unburnt	



Annual burn



Unburned



Fire effects on herbaceous community structure

Predictions:

- Long-term exclusion of fire would have the greatest impact on herbaceous community structure
- The effects of changes in fire frequency and season on the herbaceous community would be manifest mainly through changes in fire intensity
- Herbaceous community structure (grass diversity, composition) of sites experiencing more frequent and intense fires would be impacted more than sites with less frequent and intense fires

EBP Fire Regimes



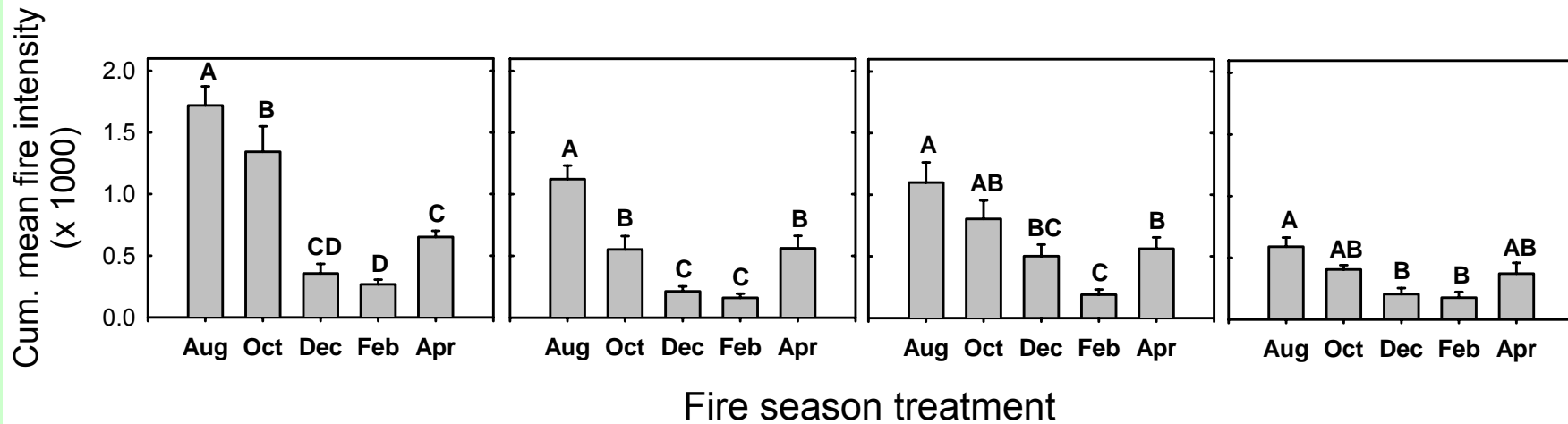
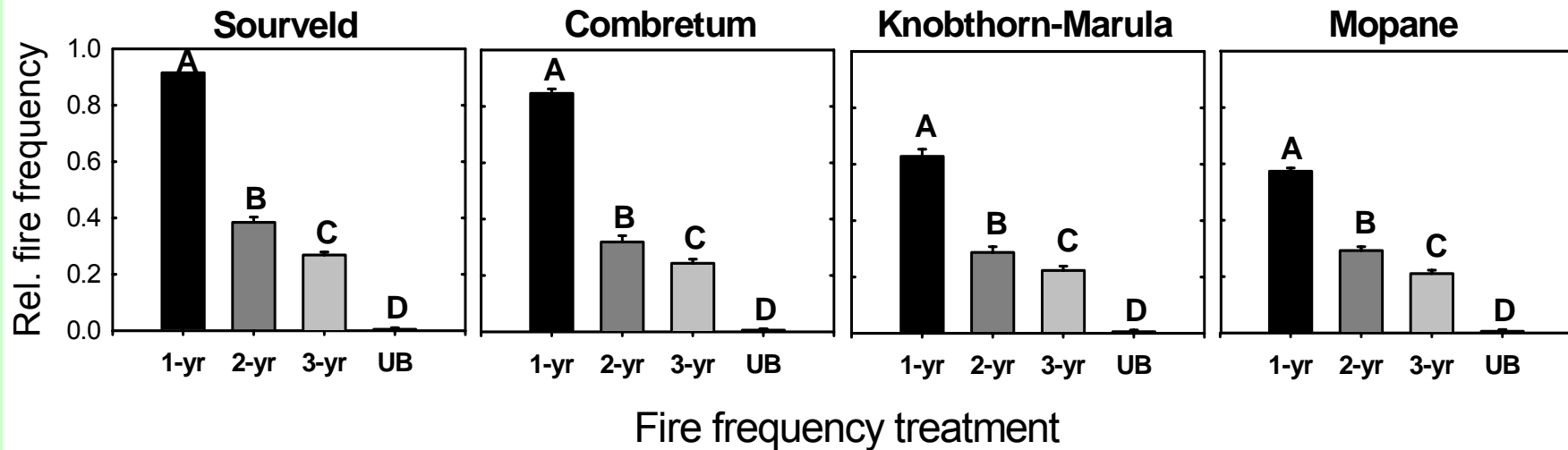
1. Relative fire frequency

- *Biggs et al. 2003*
- number of fires that occurred over the duration of the experiment divided by the total burn period for a study site

2. Cumulative mean fire intensity

- Data from 783 plot burns conducted between 1982 and 2003
- average intensity of all fires on a plot X number of fires for a plot over the study period, divided by the period over which those fires occurred

Fire frequency and intensity



$r^2 = 0.63, P < 0.001$

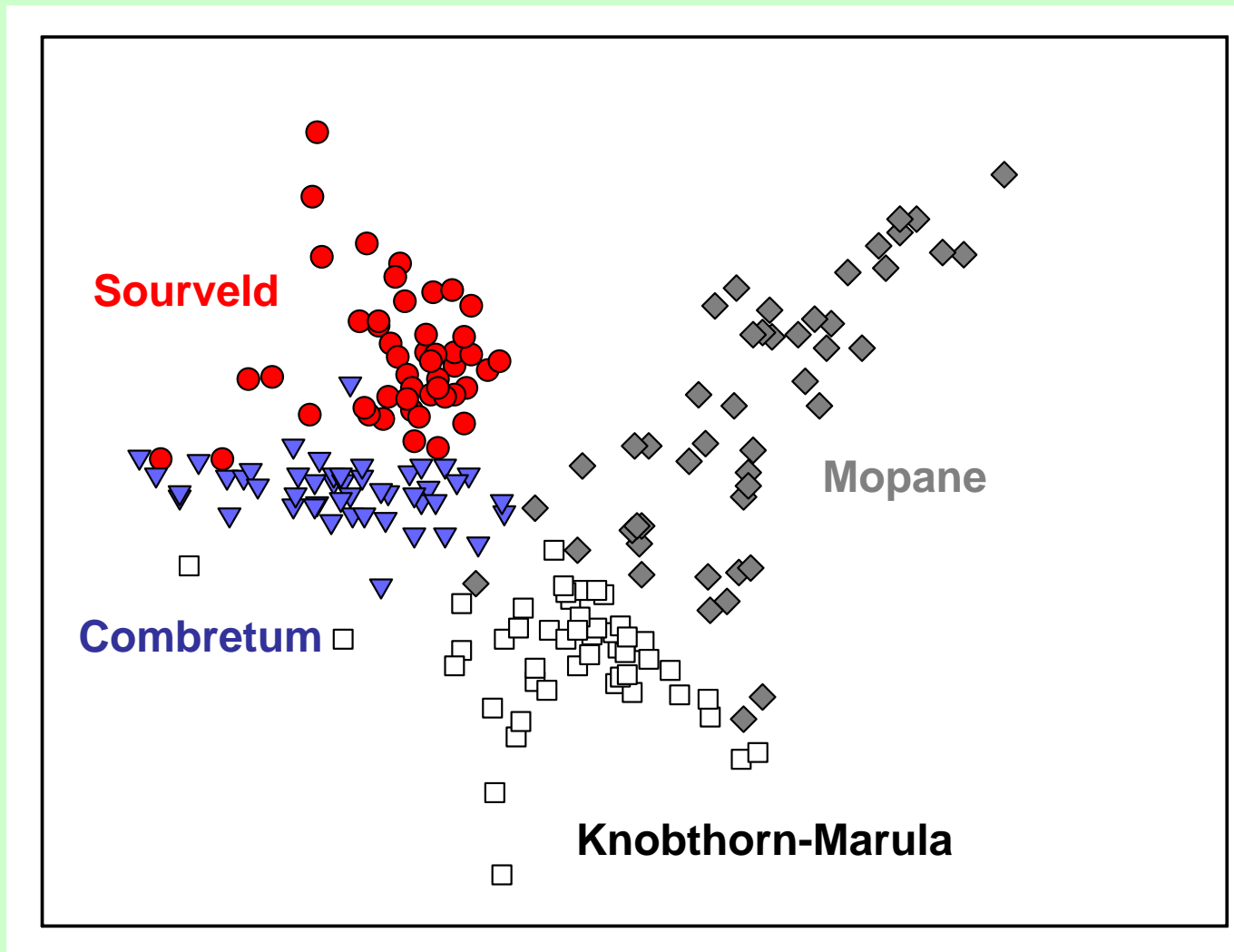
Vegetation Sampling

- Herbaceous vegetation was sampled twice
 - Pretreatment (1954-1956) – *Levy bridge*
 - After ~45 yrs – *Step-point*
- Only grasses were identified to species (all else lumped into 'forb' category)
- Calculated relative abundance (frequency) of each grass species

Assessing changes in community structure and composition

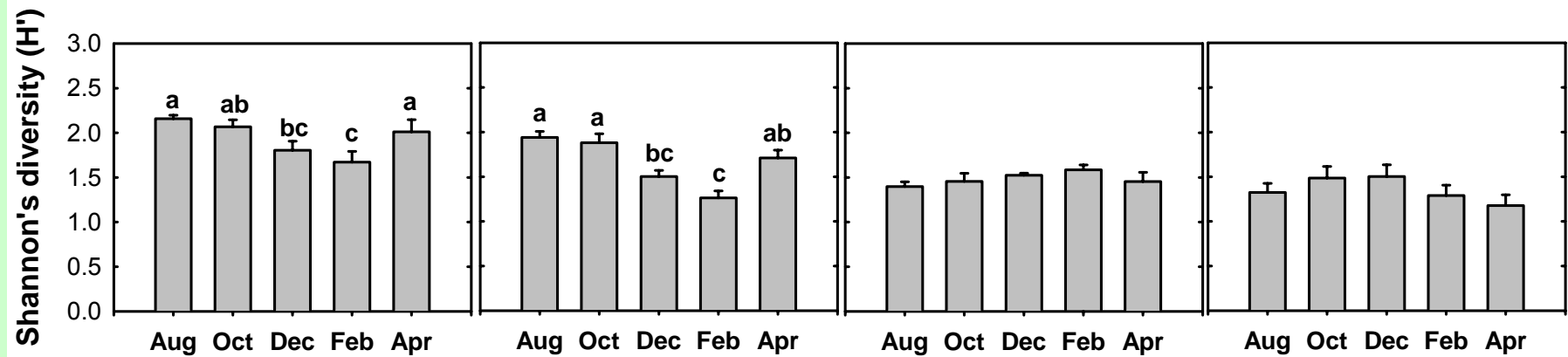
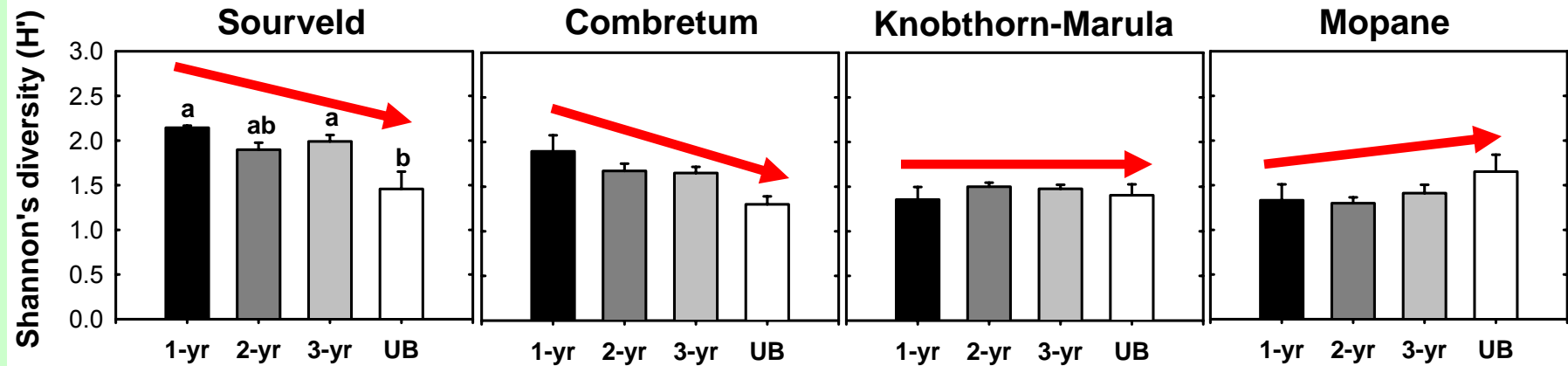
- **Community structure**
 - Richness, evenness (J'), Shannon's diversity (H'), Dominance
- **Community composition**
 - Non-metric multidimensional scaling (MDS)
 - Analysis of similarity (ANOSIM) – test for differences among fire treatments in ordinate space
 - Similarity percentage analysis (SIMPER)

Composition differs between the vegetation types

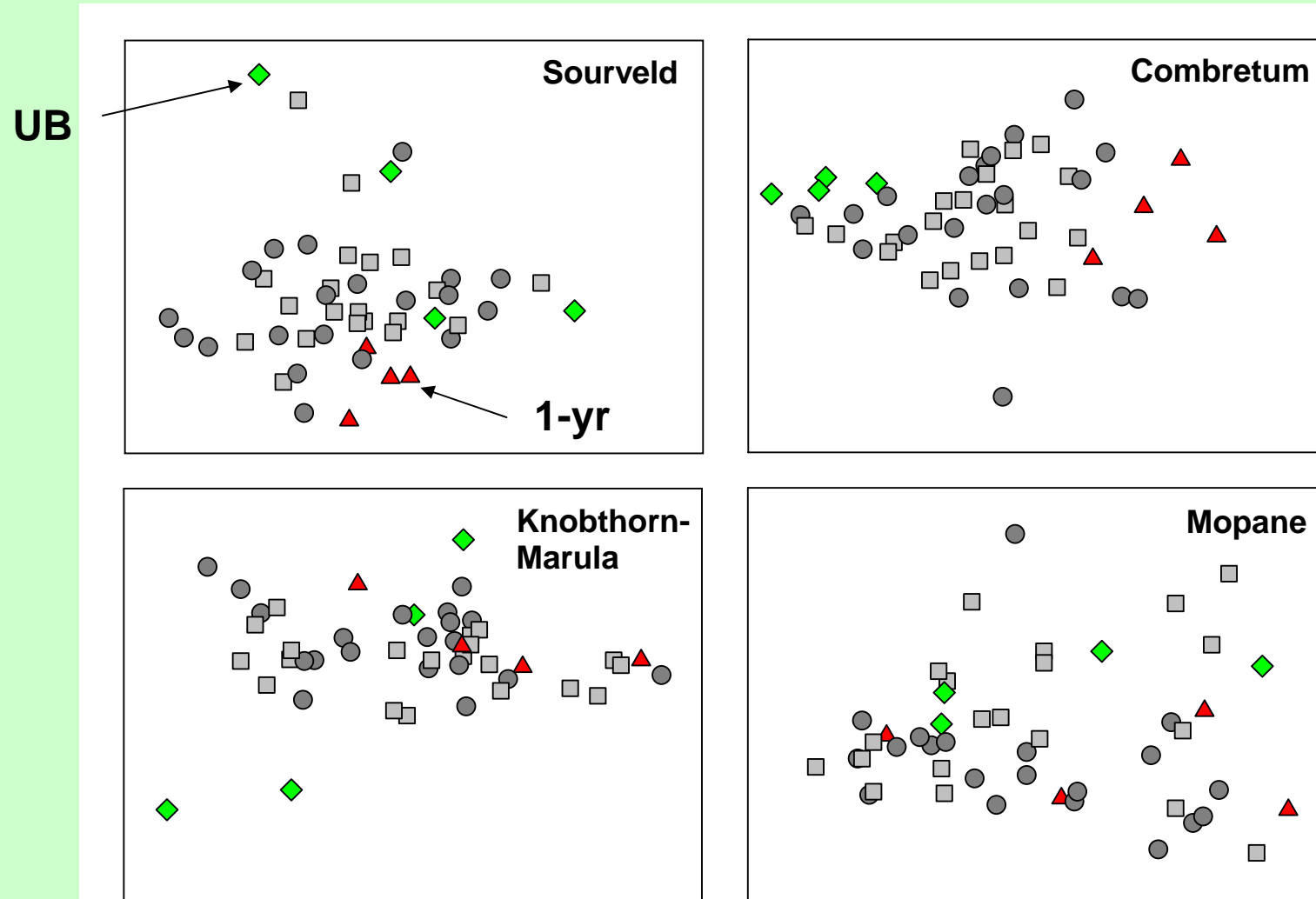


Distance between points reflects the degree of dissimilarity among the EBPs

Effects of fire frequency and season on grass diversity



Changes in composition with fire frequency



Distance between points reflects the degree of dissimilarity among the EBP's

Fire frequency and composition

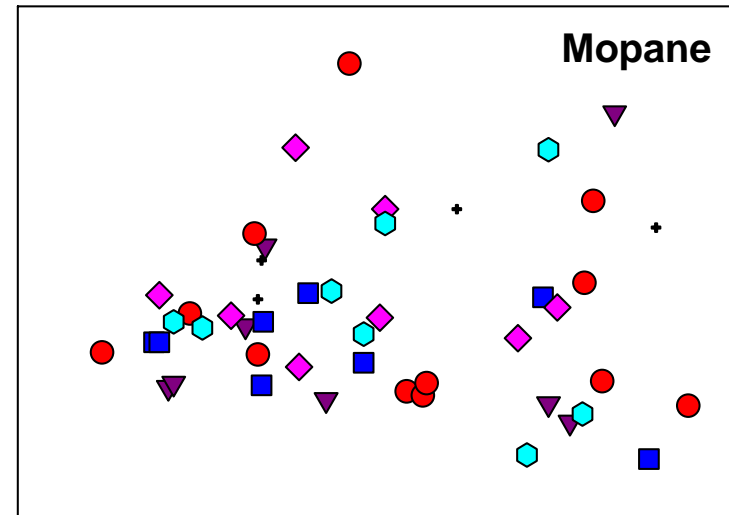
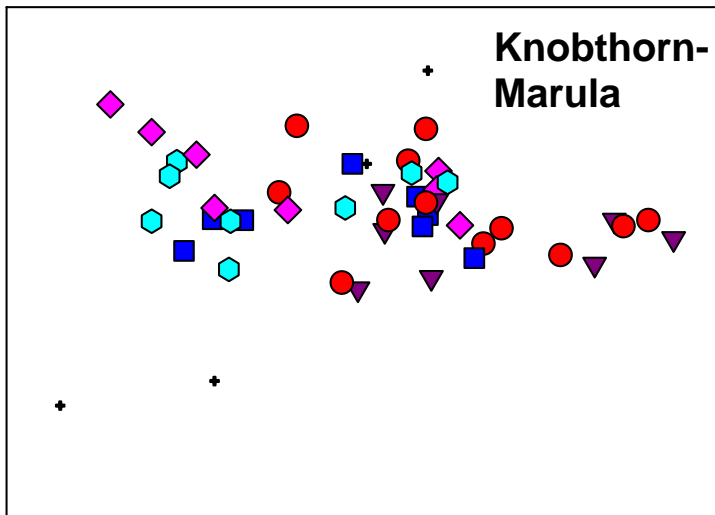
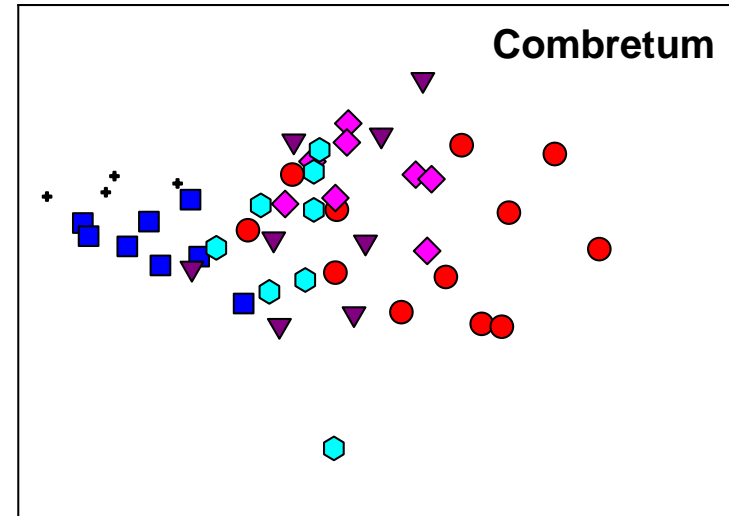
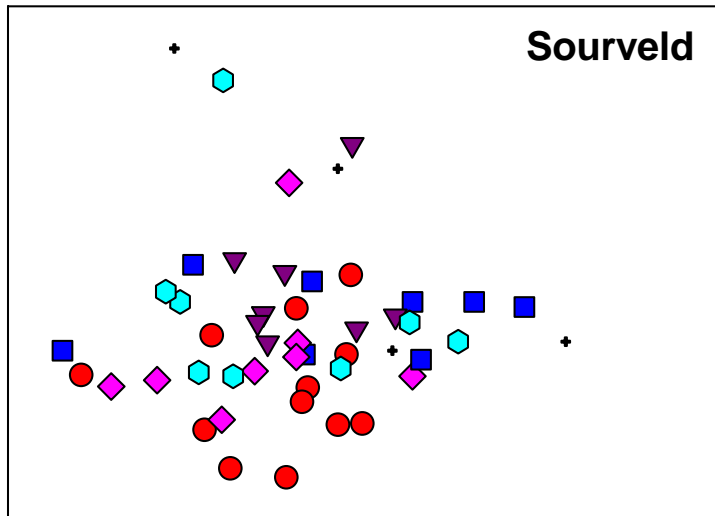
Results from ANOSIM analyses:

	Sourveld	Combretum	Knobthorn- Marula	Mopani
Fire	0.097 (0.048)	0.206 (0.001)	0.124 (0.016)	0.036 (0.19)
1-yr vs. 2-yr	0.016 (0.437)	0.375 (0.006)	0.044 (0.357)	-
1-yr vs. 3-yr	0.134 (0.213)	0.704 (0.002)	-0.005 (0.502)	-
2-yr vs. 3-yr	-0.025 (0.804)	-0.011 (0.584)	0.005 (0.347)	-
1-yr vs. UB	0.469 (0.029)	1.000 (0.029)	0.255 (0.057)	-
2-yr vs. UB	0.349 (0.020)	0.257 (0.036)	0.509 (0.011)	-
3-yr vs. UB	0.426 (0.019)	0.412 (0.002)	0.524 (0.004)	-

Composition of the unburnt treatment is most dissimilar

Fire season and composition

- Aug
- ◆ Oct
- ⬡ Dec
- Feb
- ▼ Apr
- + UB



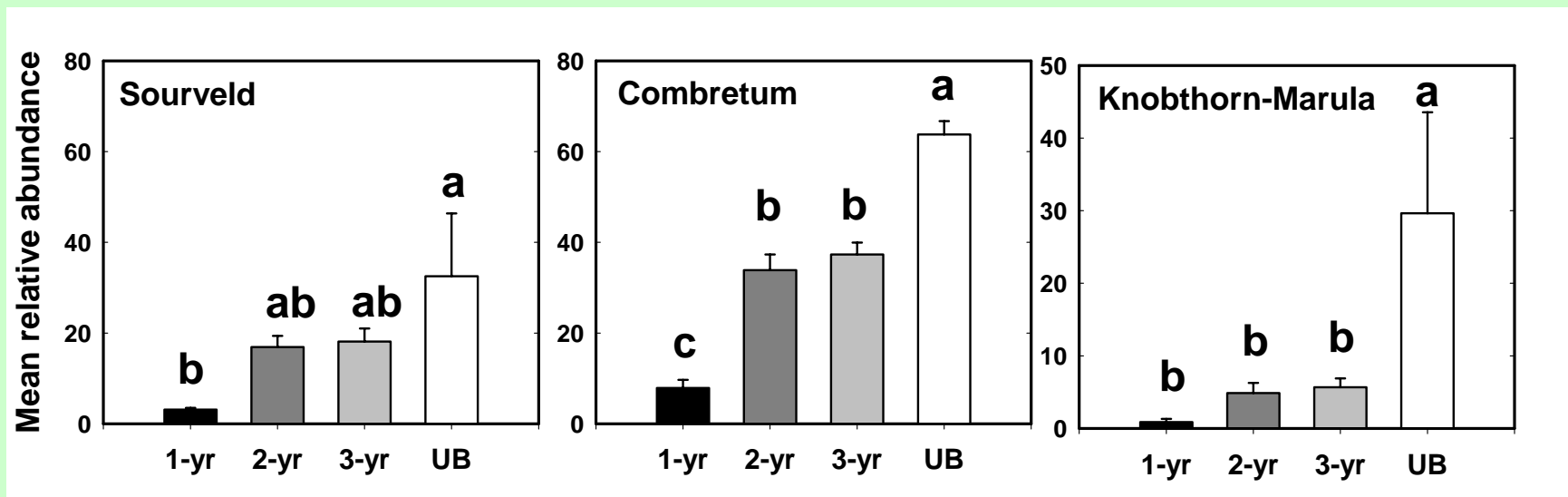
Fire season and composition

Results from ANOSIM analyses:

	Sourveld	Combretum	Knobthorn- Marula	Mopani
Season	0.101 (0.016)	0.334 (0.001)	0.110 (0.002)	-0.058 (0.947)
Aug vs. Oct	0.038 (0.273)	0.042 (0.262)	0.163 (0.058)	-
Aug vs. Dec	0.176 (0.030)	0.319 (0.004)	0.252 (0.012)	-
Aug vs. Feb	0.266 (0.008)	0.683 (0.001)	0.028 (0.319)	-
Aug vs. Apr	0.084 (0.159)	0.114 (0.082)	-0.060 (0.728)	-
Feb vs. Oct	0.149 (0.070)	0.919 (0.001)	0.045 (0.249)	-
Feb vs. Dec	-0.002 (0.364)	0.540 (0.001)	0.002 (0.338)	-
Feb vs. Apr	0.084 (0.134)	0.511 (0.001)	0.083 (0.187)	-
Apr vs. Oct	0.103 (0.099)	0.145 (0.063)	0.295 (0.008)	-
Apr vs. Dec	0.062 (0.181)	0.050 (0.193)	0.039 (0.007)	-
Oct vs. Dec	-0.011 (0.469)	0.243 (0.005)	-0.033 (0.573)	-

A few key species drove community responses

Panicum maximum increased in abundance with decreasing fire frequency



Sourveld: *Heteropogon contortus*

Combretum: *Eragrostis rigidior*

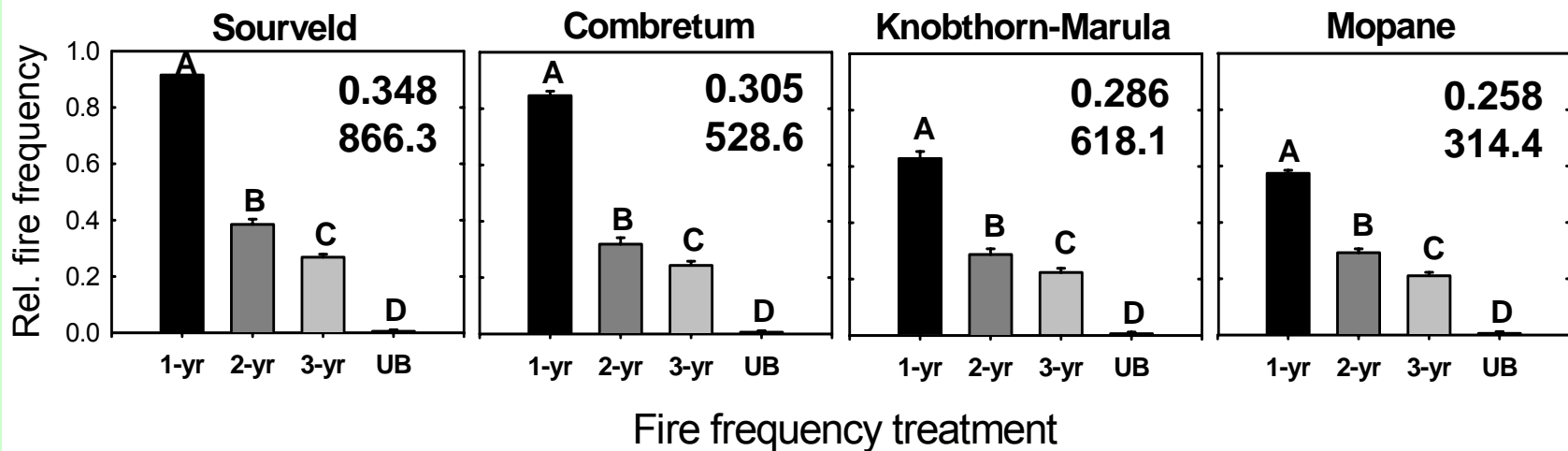
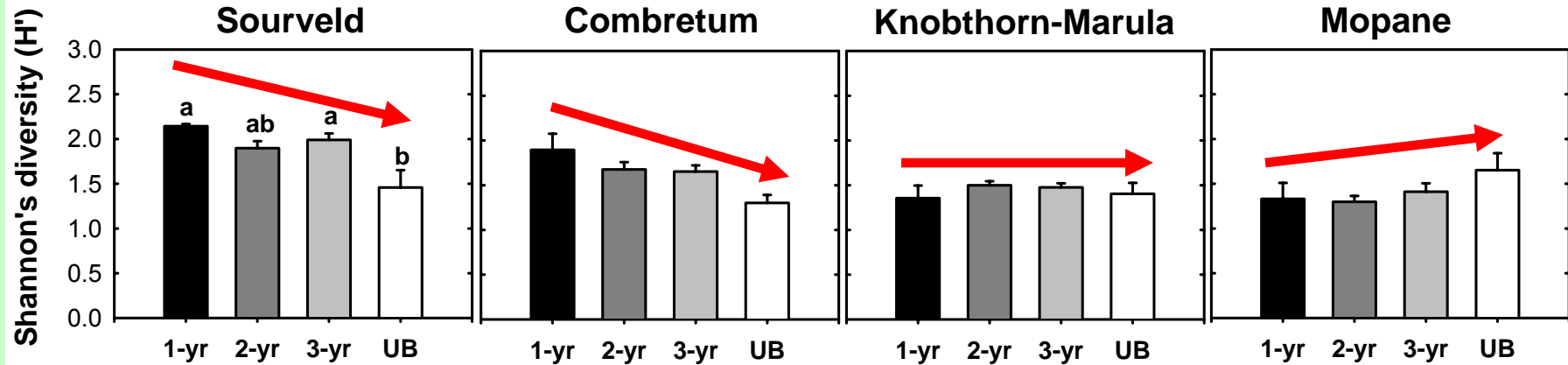
Knobthorn-marula: *Urochloa mosambicensis*

Fire effects on herbaceous community structure

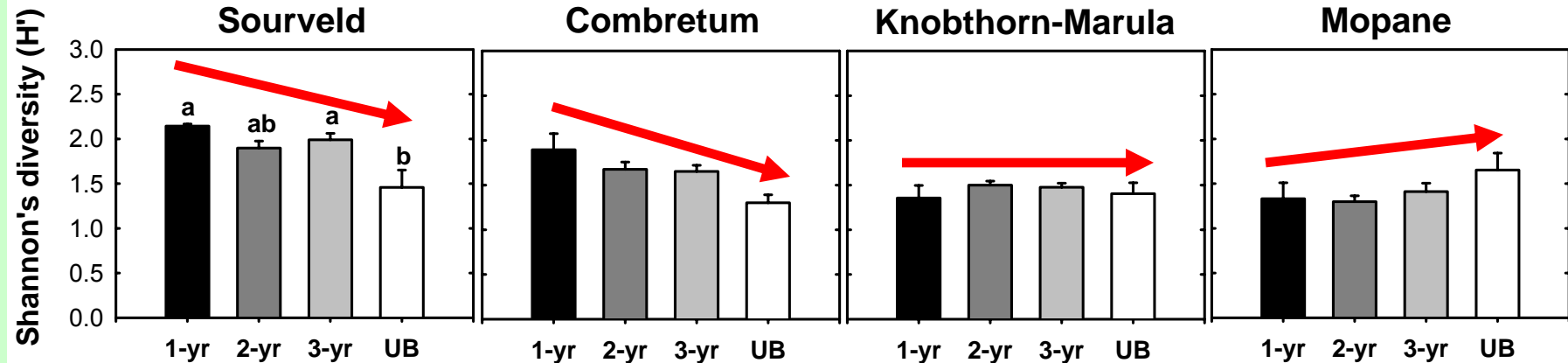
Predictions:

- Long-term exclusion of fire would have the greatest impact on herbaceous community structure
 - **UB >>> 1-yr = 2-yr = 3-yr**
- The effects of changes in fire frequency and season on the herbaceous community would be manifest mainly through changes in fire intensity
 - **Relative fire frequency and intensity were strongly correlated – both important**
- Herbaceous community structure (grass diversity, composition) of sites experiencing more frequent and intense fires would be impacted more than sites with less frequent and intense fires
 - **Sourveld = Combretum > Knobthorn-Marula >> Mopane**

Fire effects on herbaceous community structure



Fire effects on herbaceous community structure varies with precipitation



← Precipitation

Impact on community structure & composition

