

Supplementary material

Dynamics of the ground layer communities of tropical eucalypt woodlands of northern Queensland

V. J. Neldner^{A,B} and D. W. Butler^A

^AQueensland Herbarium, Department of Environment and Science, Mt Coot-tha Road, Toowong, Qld 4066, Australia.

^BCorresponding author. Email: john.neldner@des.qld.gov.au

Table S1. The frequency and mean cover of native species grouped by lifeform across all samplings

	Site 1		Site 1A		Site 2		Site 3		Site 4	
	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)
Native graminoid species										
<i>Abildgaardia ovata</i>					28					
<i>Alloteropsis semialata</i>	78	0.5	100	3.2	89	1	100	2.2	3.6	94
<i>Ancistrachne uncinulata</i>					11	0.1			0.3	17
<i>Arundinella setosa</i>			13	0.1					2.8	100
<i>Aristida utilis</i>	6	0.1			78	0.4	89	0.4		
<i>Arundinella setosa</i>					100	0.5	78	0.7		
<i>Bothriochloa bladhii</i> subsp. <i>bladhii</i>	78	1.7	69	0.5						
<i>Bulbostylis barbata</i>					50	0.5				
<i>Byblis liniflora</i>					22	0.1	22	0.1		
<i>Capillipedium parviflorum</i>	78	1.7	94	0.4	6	0.1			0.1	50
<i>Cartonema spicatum</i>					6	0.1	44	0.1		
<i>Chloris lobata</i>			6	0.1						
<i>Chlorophytum laxum</i>					6	0.1				
<i>Chrysopogon fallax</i>			6	0.1	50	0.2				
<i>Cymbopogon ambiguus</i>					6	0.1	72	0.3		
<i>Cymbopogon bombycinus</i>					6	0.1				
<i>Cyperus castaneus</i> var. <i>castaneus</i>					22	0.1				
<i>Cyperus pulchellus</i>			6	0.1						
<i>Cyperus scaber</i>			6	0.1					0.2	61
<i>Dianella nervosa</i>					28	0.1	6	0.1	1.2	89
<i>Digitaria gibbosa</i>					6	0.1	72	0.4		
<i>Digitaria parviflora</i>			6	0.1						
<i>Dimeria ornithopoda</i>					11	0.4				
<i>Eragrostis brownii</i>	72	0.1	13	0.4	39	0.2			0.1	6
<i>Eragrostis cumingii</i>					17	0.1				
<i>Eragrostis lacunaria</i>	11	0.1								
<i>Eragrostis spartinoides</i>			6	0.1	28	0.1	83	0.2	0.1	11
<i>Eremochloa bimaculata</i>	6	0.1	6	0.1	94	0.1	94	0.1	3.2	100
<i>Eriachne</i> sp.							6		0.2	11
<i>Eriochloa procera</i>	6	0.1	6	0.1						
<i>Fimbristylis depauperata</i>									0.1	11
<i>Fimbristylis dichotoma</i>			31	0.9	11	0.2	83	1.5		
<i>Fimbristylis recta</i>					61	0.1	67	0.1		
<i>Fimbristylis</i> sp.	100	1	100	1.7	61	0.6	11	0.7	0.1	17
<i>Haemodorum coccineum</i>					22	0.1	22	0.1		
<i>Heteropogon contortus</i>	28	0.3			28	1.1	100	2.5		
<i>Heteropogon triticeus</i>	100	8.1	88	2.9	94	2.1	100	3.7	1.1	100
<i>Iphigenia indica</i>	6	0.1			11	0.1			0.1	44
<i>Ischaemum rugosum</i>			6	0.1						
<i>Lomandra decomposita</i>					39	0.1	17	0.2	0.4	11
<i>Lomandra filiformis</i> subsp. <i>filiformis</i>							11	0.1		

	Site 1		Site 1A		Site 2		Site 3		Site 4	
	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)
<i>Lomandra multiflora</i> subsp. <i>multiflora</i>	6	0.1					33	0.1	0.2	39
<i>Mnesithea formosa</i>					56	0.6	72	0.6		
<i>Mnesithea granularis</i>					33	0.1				
<i>Mnesithea rottboellioides</i>					72	0.1			8.3	100
<i>Murdannia graminea</i>					17	0.1			0.1	17
<i>Murdannia vaginata</i>									0.1	6
<i>Panicum decompositum</i> var. <i>tenuius</i>	78	0.3	56	0.1						
<i>Panicum effusum</i> var. <i>effusum</i>	33	0.4	25	0.3	44	0.1			0.1	6
<i>Paspalidium distans</i>			38	0.1						
<i>Pseudopogonatherum contortum</i>	67	0.2	31	0.1	67	0.1	28	0.1		
<i>Pterocaulon sphacelatum</i>	89	0.1	19	0.1	22	0.1	44	0.1	0.1	11
<i>Rhynchospora heterochaeta</i>			6	0.1	89	0.2	89	0.1		
<i>Sarga plumosum</i>	67	0.7	69	0.7	11	0.2			0.1	17
<i>Schizachyrium occultum</i>					50	3.7				
<i>Schizachyrium pachyarthron</i>							100	4		
<i>Schizachyrium pseudeulalia</i>	17	0.1	69	0.1	50	2.2				
<i>Scleria brownii</i>	44	0.2	56	0.4	17	0.1	17	0.1	0.3	72
<i>Setaria surgens</i>							22	0.2		
<i>Sporobolus caroli</i>			6	0.1						
<i>Sporobolus lenticularis</i>					28	0.1				
<i>Thaumastochloa major</i>			63	0.1	94	2.3	89	1		
<i>Themeda triandra</i>	100	53.5	100	42.2	100	20.6	100	31.3	36	100
<i>Thysanotus banksii</i>							33	0.1		
<i>Urochloa polyphylla</i>							72	0.2		
Native forb species										
<i>Acmella grandiflora</i> var. <i>brachyglossa</i>									94	0.1
<i>Afrohybanthus enneaspermus</i>	6	0.4			28	0.1	78	0.2		
<i>Afrohybanthus stellarioides</i>										
<i>Blumea saxatilis</i>	33	0.1	25	0.1	83	0.2	33	0.3	6	0.1
<i>Brunoniella acaulis</i> subsp. <i>acaulis</i>	94	2.5			72	0.2				
<i>Buchnera gracilis</i>	6	0.1	94	2.1	67	0.1				
<i>Buchnera linearis</i>					11	0.1	61	0.1		
<i>Buchnera tetragona</i>					11	0.1				
<i>Camptacra gracilis</i>	28	0.2	6	0.1	0				11	0.1
<i>Centranthera cochinchinensis</i>					6	0.1				
<i>Chamaecrista absus</i> var. <i>absus</i>					72	0.2	94	0.8		
<i>Chamaecrista nomame</i> var. <i>nomame</i>	44	0.1	88	0.3	94	0.6	61	0.4	89	0.6
<i>Cheilanthes brownii</i>					33	0.1	89	0.3		
<i>Cheilanthes nitida</i>					83	0.3	89	0.2	28	0.1
<i>Cheilanthes nudiuscula</i>							11	0.2		
<i>Coronidium lanuginosum</i>							33	0.1	22	0.1
<i>Coronidium rupicola</i>	6	0.1								

	Site 1		Site 1A		Site 2		Site 3		Site 4	
	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)
<i>Corybas barbarae</i>									28	0.1
<i>Crotalaria aridicola</i> subsp. <i>aridicola</i>									6	0.1
<i>Crotalaria brevis</i>										
<i>Crotalaria calycina</i>					44	0.2	67	0.1	67	0.3
<i>Crotalaria medicaginea</i> var. <i>medicaginea</i>					100	0.4	94	0.6	83	0.3
<i>Crotalaria montana</i>	61	0.2	69	0.3	89	0.3	94	0.2	28	0.3
<i>Cyanthillium cinereum</i>	67	0.2	25	0.2	100	0.2	78	0.1	100	0.2
<i>Desmodium filiforme</i>	6	0.1	6	0.1	89	2.2	89	0.7		
<i>Drosera spatulata</i>					6	0.1	11	0.1		
<i>Drynaria rigidula</i>									6	0.1
<i>Eriosema chinense</i>	6	0.1					33	0.1		
<i>Euphorbia mitchelliana</i> var. <i>mitchelliana</i>	44	0.1	56	0.1	22	0.2	72	0.2		
<i>Evolvulus alsinoides</i> var. <i>decumbens</i>	44	0.1			39	0.1	61	0.3		
<i>Gonocarpus acanthocarpus</i>									6	0.1
<i>Goodenia pilosa</i>			19	0.1	67	0.3	67	0.5		
<i>Heliotropium peninsulare</i>					17	0.1	67	0.1		
<i>Hypericum gramineum</i>					6	0.1				
<i>Indigofera linnaei</i>							6	0.1		
<i>Indigofera pratensis</i>	22	0.1	6	0.1					6	0.1
<i>Indigofera scabrella</i>							6	0.1		
<i>Ipomoea polymorpha</i>							17	0.2		
<i>Lagenophora gracilis</i>	6	0.1					6	10	6	0.1
<i>Lindernia</i> sp.							6	0.1		
<i>Melochia corchorifolia</i>			13	0.1						
<i>Mitrasacme connata</i>	6	0.1					72	0.2		
<i>Mitrasacme prolifera</i>					17	0.1	0		17	0.1
<i>Mitrasacme pygmaea</i>	11	0.2	6	0.1	56	0.2	72	0.1	6	0.1
<i>Neptunia gracilis</i> forma <i>glandulosa</i>	11	0.1	19	0.1						
<i>Oldenlandia laceyi</i>					17	0.1	33	0.1		
<i>Oldenlandia mitrasacmoides</i>					11	0.1				
<i>Phacellothrix cladochaeta</i>					89	0.5	94	0.4		
<i>Phyllanthus fuernrohrii</i>					67	0.1				
<i>Phyllanthus simplex</i>	6	0.1								
<i>Phyllanthus virgatus</i>	44	0.1	81	0.1	94	0.2	67	0.1	83	0.2
<i>Pimelea cornucopiae</i>					89	0.4	72	0.2		
<i>Polygala exsuarrosa</i>					17	0.1	61	0.2		
<i>Polygala longifolia</i>	72	0.1	81	0.1	22	0.1	50	0.1		
<i>Polygala rhinanthoides</i>							6	0.1		
<i>Poranthera microphylla</i>					72	0.1	61	0.1	39	0.2
<i>Pycnospora lutescens</i>					50	0.1				

	Site 1		Site 1A		Site 2		Site 3		Site 4	
	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)
<i>Rostellularia adscendens</i> var. <i>latifolia</i>	89	0.5	6	0.1	11	0.1	11	0.1	83	0.5
<i>Rotala diandra</i>										
<i>Spermacoce cristulata</i>					56	0.2	72	0.3	11	0.2
<i>Stackhousia intermedia</i>					61	0.1	67	0.1		
<i>Striga parviflora</i>	6	0.1			11	0.1	6	0.1		
<i>Stylidium capillare</i>					17	0.1				
<i>Tacca leontopetaloides</i>			13	0.1			22	0.1	6	0.1
<i>Tephrosia filipes</i> forma <i>vestita</i>							28	0.1		
<i>Tephrosia juncea</i>					100	0.6	94	0.3		
<i>Tephrosia purpurea</i> var. <i>sericea</i>							6	0.4		
<i>Tricoryne anceps</i> subsp. <i>anceps</i>					11	0.1	61	0.1		
<i>Tricoryne anceps</i> subsp. <i>pteroaulon</i>									89	0.1
<i>Wahlenbergia caryophylloides</i>					56	0.2				
<i>Wahlenbergia gracilis</i>									28	0.1
<i>Zornia muriculata</i> subsp. <i>muriculata</i>	56	0.1	88	0.4	94	3.2	94	1.8	72	0.2
Native twining forb species										
<i>Aristolochia holtzei</i>	22	0.1					6	0.1		
<i>Cayratia trifolia</i>	100	0.8	38	0.1						
<i>Commelina ensifolia</i>							11	0.1	39	0.2
<i>Desmodium rhytidophyllum</i>	6	0.1			44	0.2			67	0.1
<i>Flemingia parviflora</i>									100	4.3
<i>Galactia tenuiflora</i> forma <i>sericea</i>	28	0.2							44	0.8
<i>Glycine curvata</i>	72	0.5			39	0.1	17	0.3	89	2
<i>Glycine tomentella</i>									6	1.3
<i>Ipomoea eriocarpa</i>					6	0.1	83	0.3	11	0.1
<i>Ipomoea graminea</i>	22	0.1								
<i>Marsdenia viridiflora</i> subsp. <i>tropica</i>	39	0.2								
<i>Vigna vexillata</i> var. <i>angustifolia</i>	6	0.1			28	0.1	11	0.2		
Native subshrub, shrub and tree species										
<i>Abelmoschus moschatus</i> subsp. <i>tuberosus</i>									11	8
<i>Acacia crassicarpa</i>					6	0.1				
<i>Acacia flavescens</i>					6	0.1	6	0.1		
<i>Acacia leiocalyx</i>			13	0.1			11	0.1		
<i>Acacia leptostachya</i>					39	0.1				
<i>Acacia whitei</i>							11	0.1		
<i>Alphitonia pomaderroides</i>					44	0.1	39	0.1		
<i>Breynia cernua</i>					6	0.1				
<i>Breynia oblongifolia</i>					6	0.1			94	0.3
<i>Bursaria incana</i>							56	0.1	0	

	Site 1		Site 1A		Site 2		Site 3		Site 4	
	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)	Frequency (%)	Mean cover (%)
<i>Capparis canescens</i>	11	0.1	63	0.1					78	0.1
<i>Capparis umbonata</i>	6	0.1	13	0.1						
<i>Corymbia citriodora</i>							17	0.1		
<i>Corymbia clarksoniana</i>					22	0.1	50	0.3		
<i>Corymbia dallachiana</i>					6	0.1	22	0.1		
<i>Dodonaea malvacea</i>					6	0.1				
<i>Dolichandrone heterophylla</i>	78	0.8								
<i>Eremophila debilis</i>					72	0.1			6	0.1
<i>Erythrophleum chlorostachys</i>							78	0.2		
<i>Eucalyptus granitica</i>							50	0.3		
<i>Eucalyptus platyphylla</i>			19	0.1	17	0.1				
<i>Eucalyptus</i> sp.					50	0.2			67	0.3
<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>	39	0.1								
<i>Grevillea glauca</i>							11	0.1	17	0.1
<i>Grevillea striata</i>					22	0.1				
<i>Grewia retusifolia</i>	100	2.7	31	0.1	100	2.7	83	0.1		
<i>Hibbertia longifolia</i>							17	0.1	83	0.1
<i>Jacksonia thesioides</i>					33	0.1				
<i>Lamprolobium fruticosum</i>					44	0.1				
<i>Melaleuca monantha</i>	11	0.6								
<i>Melaleuca viridiflora</i>			13	0.1	28	0.3	56	0.3		
<i>Persoonia falcata</i>			19	0.4	33	0.1	6	0.1	50	0.1
<i>Petalostigma banksii</i>					22	0.1	72	0.8		
<i>Petalostigma pubescens</i>					39	0.1				
<i>Pimelea sericostachya</i> subsp. <i>sericostachya</i>							94	0.5		
<i>Planchonia careya</i>					39	0.4				
<i>Pogonolobus reticulatus</i>			19	0.4						

Table S2. Non-native species recorded on all sites

Only two non-native species occurred at all five sites, five at four sites, three at three sites, six at two sites & nine at only one site

Species	Sites & frequency recorded (%)	Lifeform	Annual or Perennial
<i>Ageratum houstonianum</i>	1, 2, 3 (6%), 1A (19%),4 (12%)	forb	annual
<i>Bidens pilosa</i>	4 (12%)	forb	annual
<i>Conyza canadensis</i>	2 (6%)	forb	annual
<i>Conyza sumatrensis</i>	4 (18%)	forb	annual
<i>Crassocephalum crepidioides</i>	1, 2, (12%) 4 (6%)	forb	annual
<i>Crotalaria goreensis</i>	1 (65%), 1A (31%), 2 (41%),3 (71%)	forb	annual
<i>Crotalaria lanceolata</i> subsp. <i>lanceolata</i>	2 (6%), 4 (6%)	forb	annual
<i>Crotalaria trichotoma</i>	2 (24%), 4 (6%)	forb	annual
<i>Desmodium strigillosum</i>	1 (88%), 1A (81%), 3 & 4 (24%)	forb	perennial
<i>Emilia sonchifolia</i>	1 (35%), 1A (25%), 2 (53%), 3 (18%)	forb	annual
<i>Praxelis clematidea</i>	1 (41%), 3 (29%), 4 (35%), 1A (31%), 2 (12%)	forb	annual
<i>Mitracarpus hirtus</i>	2 (88%), 3 (71%)	forb	annual
<i>Dichanthium annulatum</i>	1 (6%)	grass	annual
<i>Melinis repens</i>	1 & 1A (6%), 3 (18%), 4 (53%)	grass	annual
<i>Sporobolus jacquemontii</i>	1 & 2 (18%), 1A (19%)	grass	perennial
<i>Themeda quadrivalvis</i>	1A (56%)	grass	annual
<i>Cryptostegia grandiflora</i>	1 (29%)	shrub	perennial
<i>Lantana camara</i>	1A (6%)	shrub	perennial
<i>Sida acuta</i>	1A (19%), 4 (6%)	subshrub	perennial
<i>Sida rhombifolia</i>	1 (6%), 2 (18%)	subshrub	perennial
<i>Stylosanthes guianensis</i>	2 (24%)	subshrub	perennial
<i>Stylosanthes humilis</i>	1A & 3 (6%), 2 (12%)	subshrub	perennial
<i>Stylosanthes scabra</i>	1 (35%), 1A (75%), 2 (12%), 3 (53%)	subshrub	perennial
<i>Passiflora foetida</i>	1 (59%), 1A (13%)	twining forb	perennial
<i>Passiflora suberosa</i>	1 (6%)	twining forb	perennial

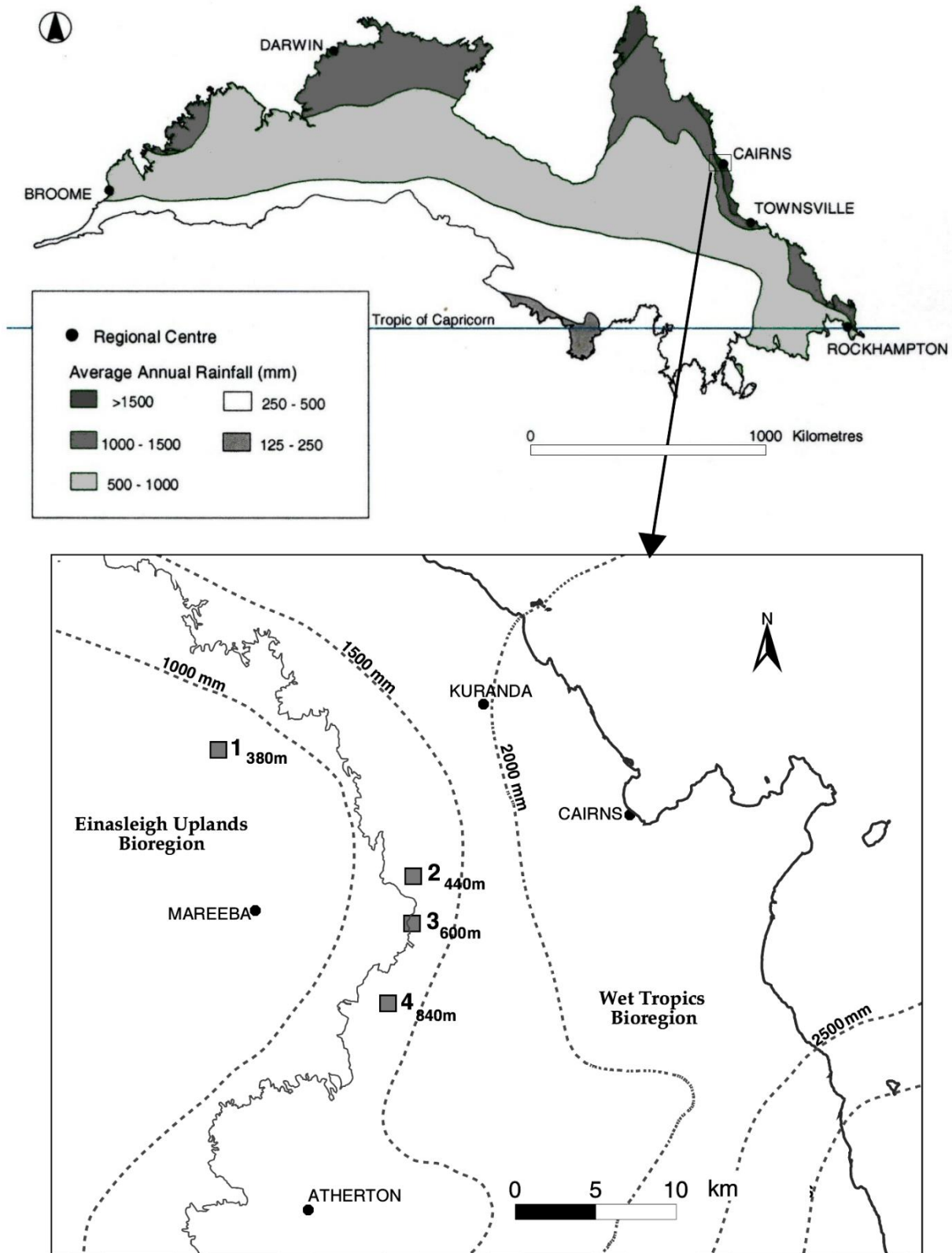


Fig. S1. Map showing location and elevation (m) for five monitoring sites (1A is 100 m from 1), in relation to Australia's tropical savannas as defined by Fox *et al.* (2001). The bioregional boundary is shown as a continuous line, with the dashed line representing annual rainfall isohyets (mm).

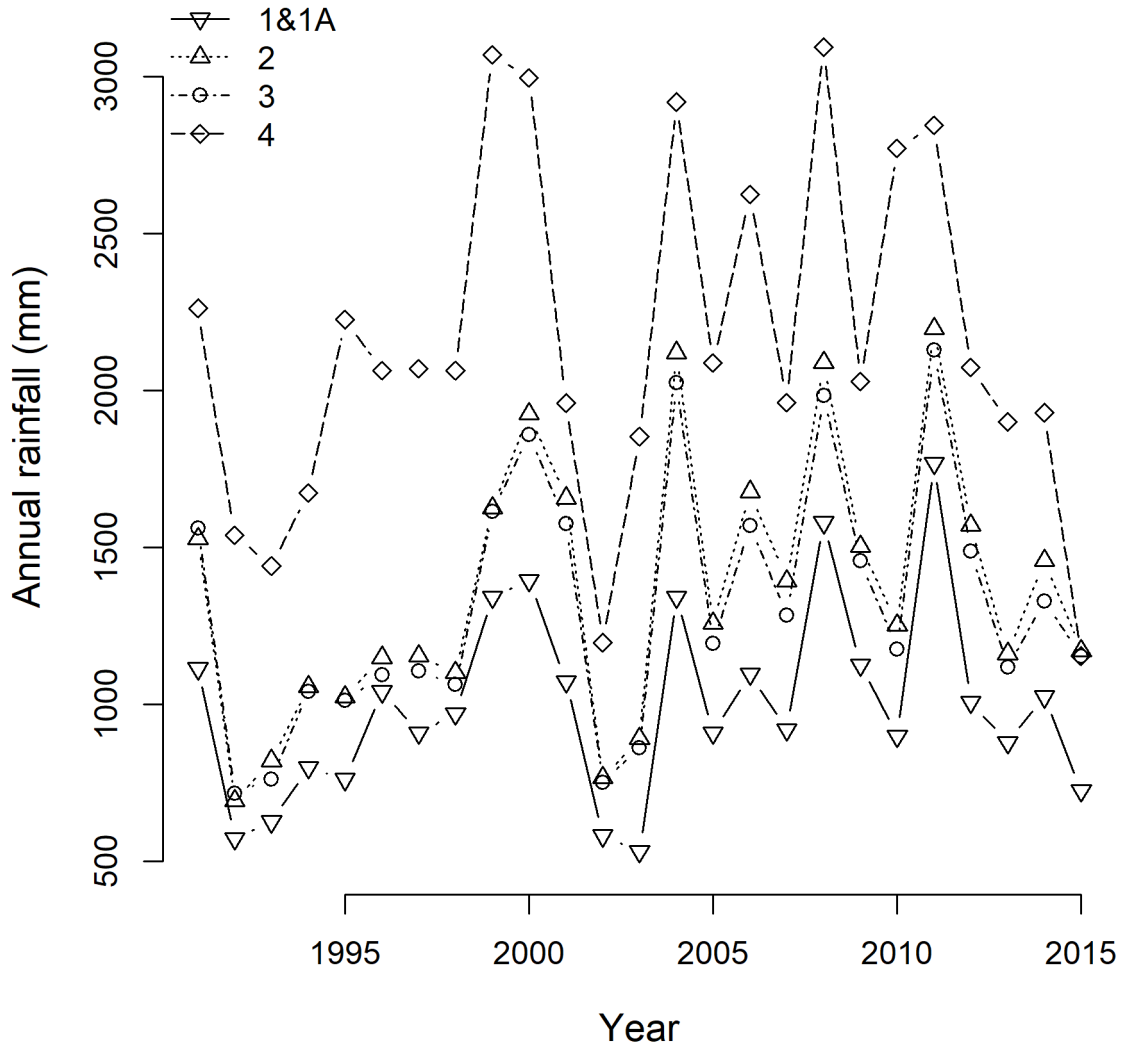


Fig. S2. Mean monthly & annual rainfall for monitoring sites derived from SILO Data Drill system (Jeffrey *et al.* 2001) which models daily rainfall and other parameters by interpolation of records from Bureau of Meteorology weather stations.

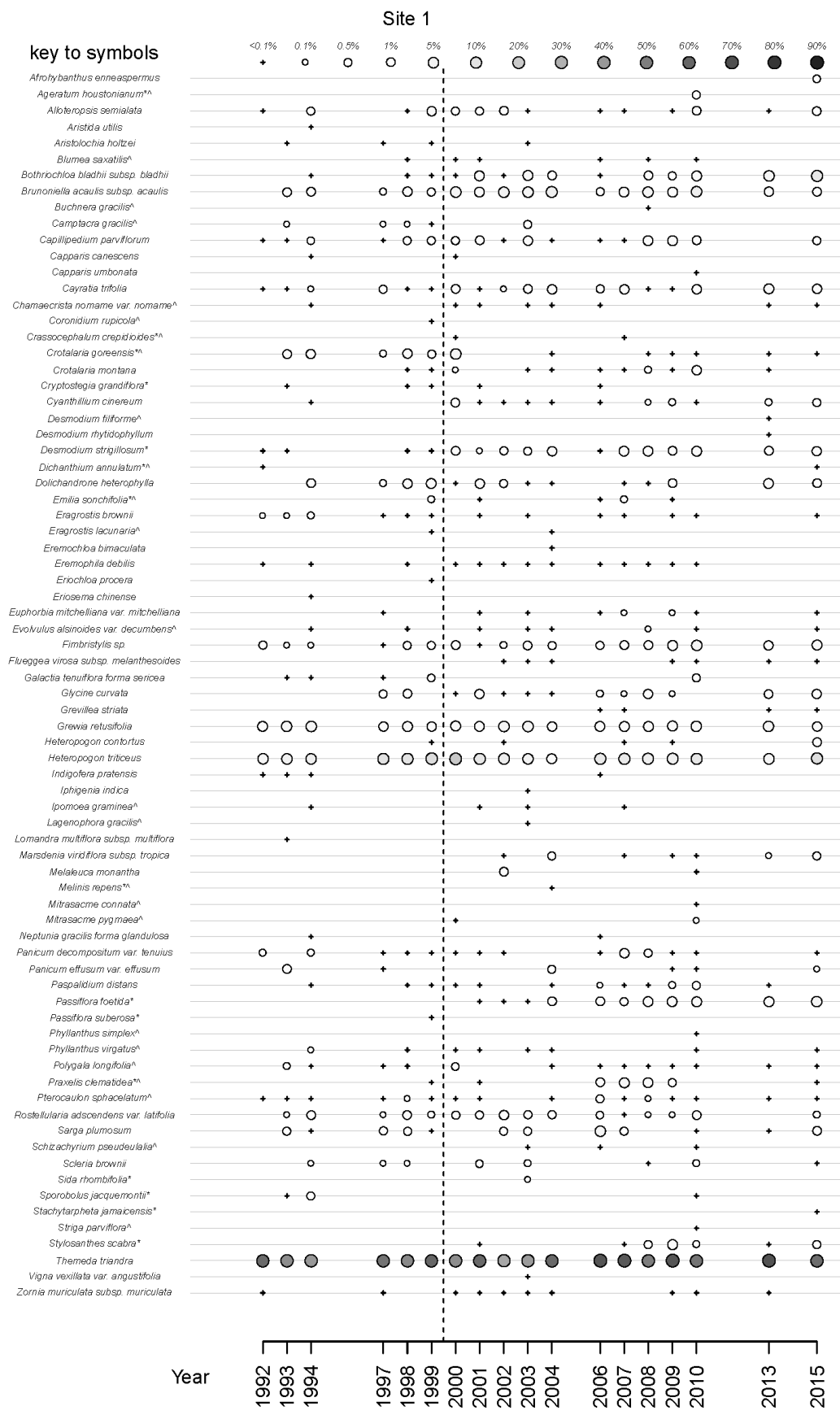


Fig. S3. Pearl diagrams of species present and cover over 23-year period for all five sites. The size of the circle represents the species cover up to a maximum size of 20% with the darker the fill in colour in the circle representing greater ground cover. A plus (+) represents that the species was present with negligible cover. The dotted lines represent a fire at the site. A circumflex (^) denotes an annual species, whereas an asterisk (*) denotes a non-native species.

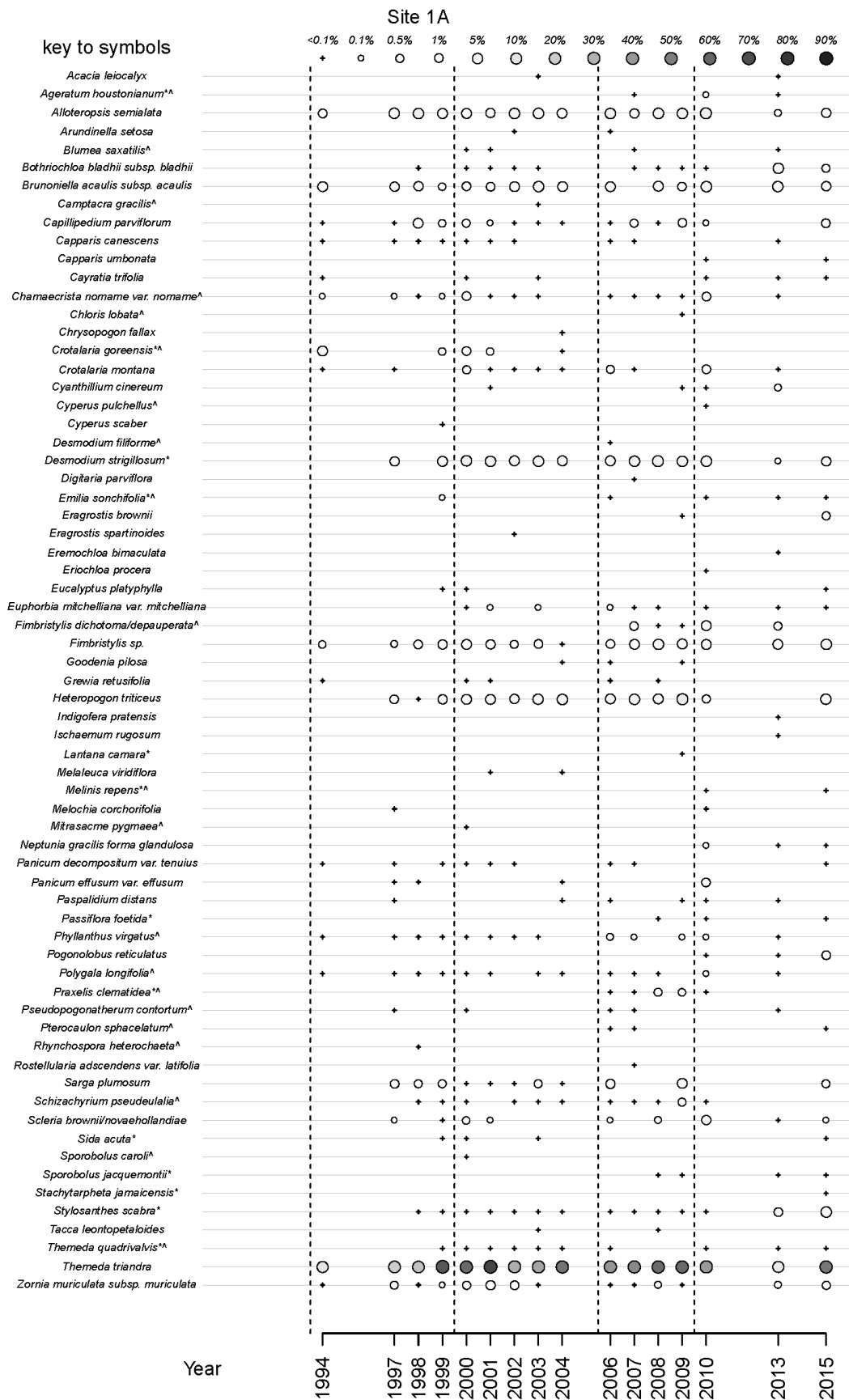


Fig. S3. (Cont.)

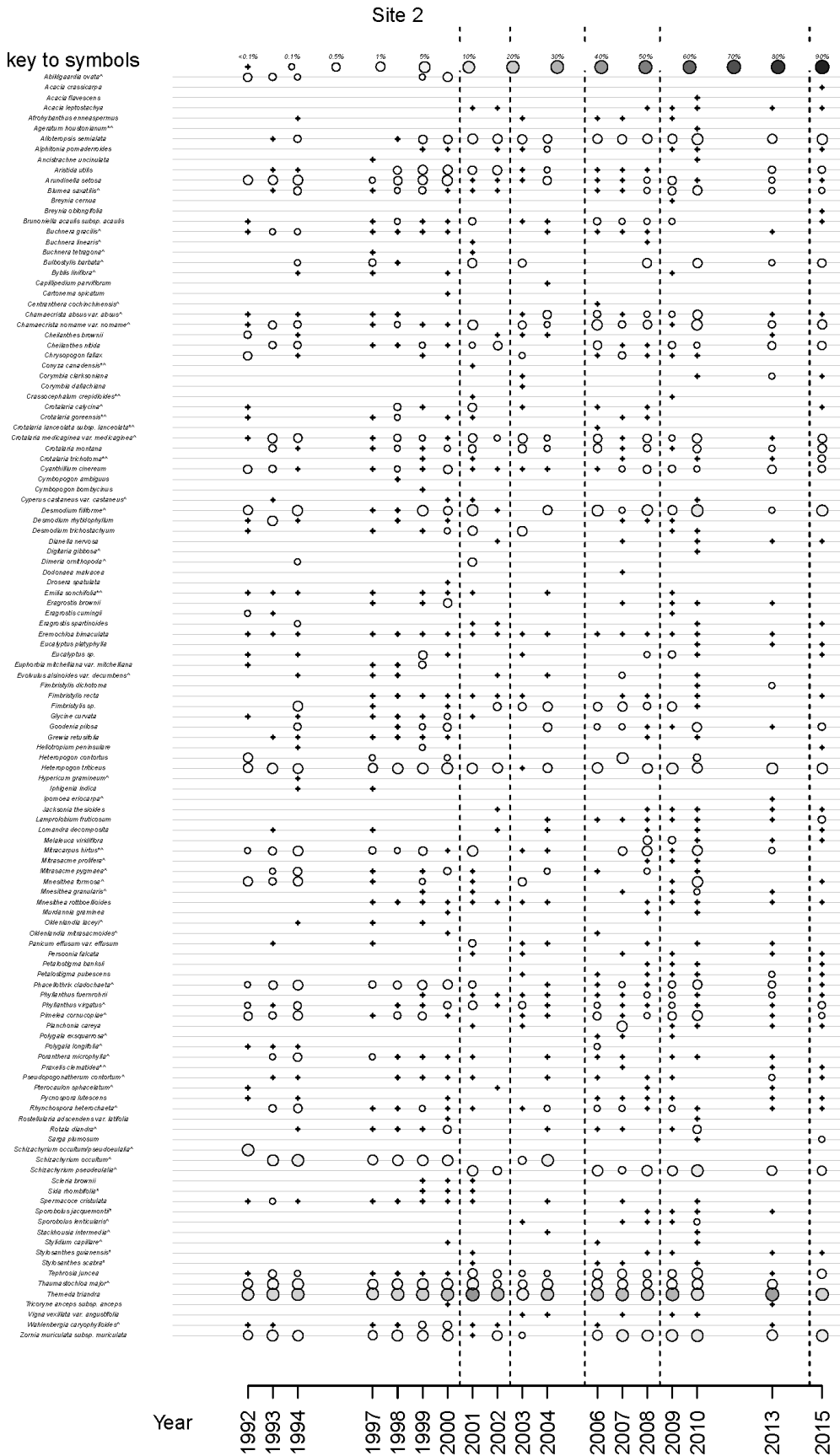


Fig. S3. (Cont.)

Site 3

key to symbols

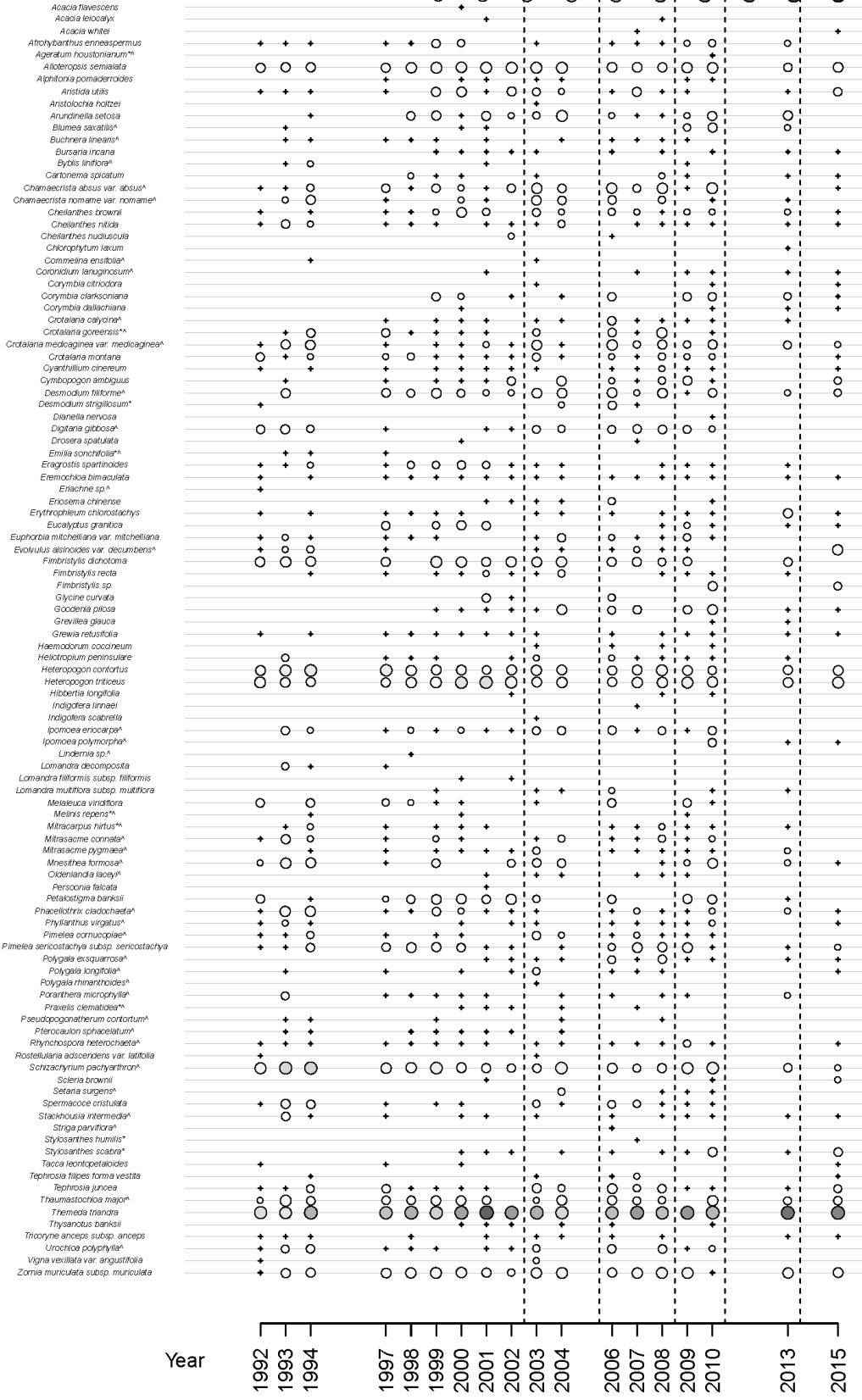


Fig. S3. (Cont.)

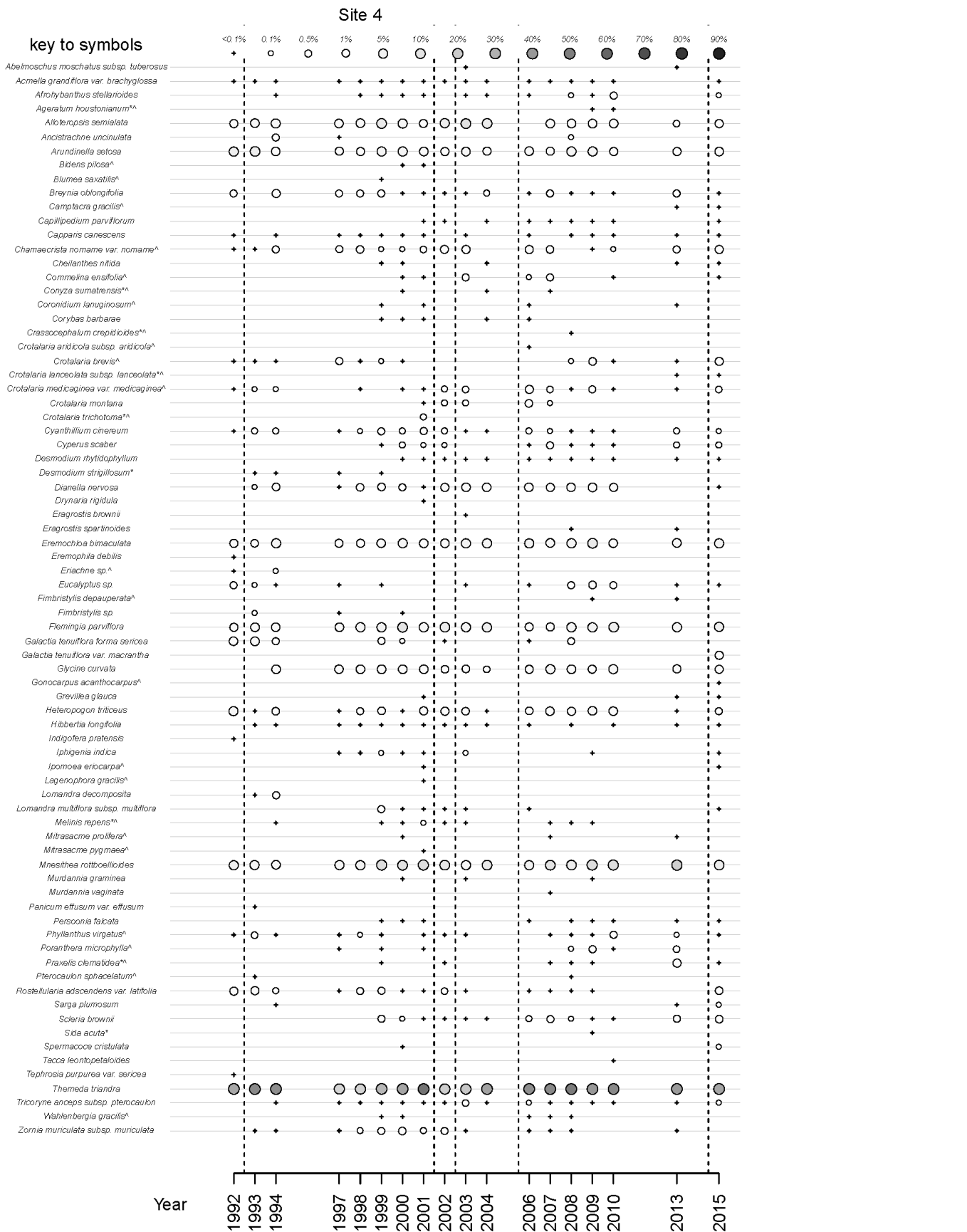


Fig. S3. (Cont.)

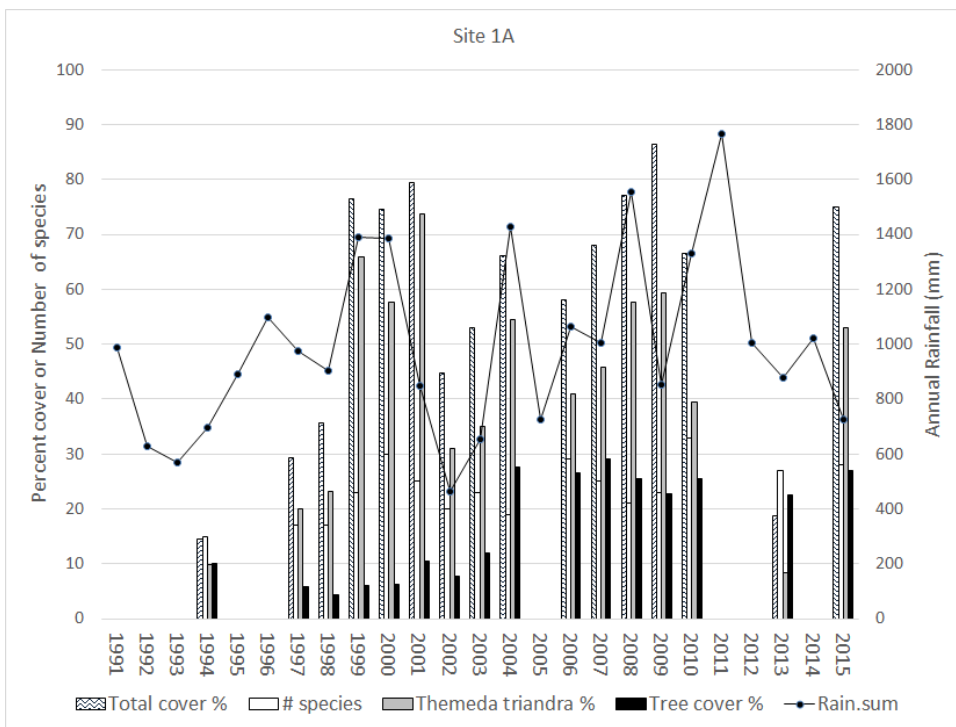
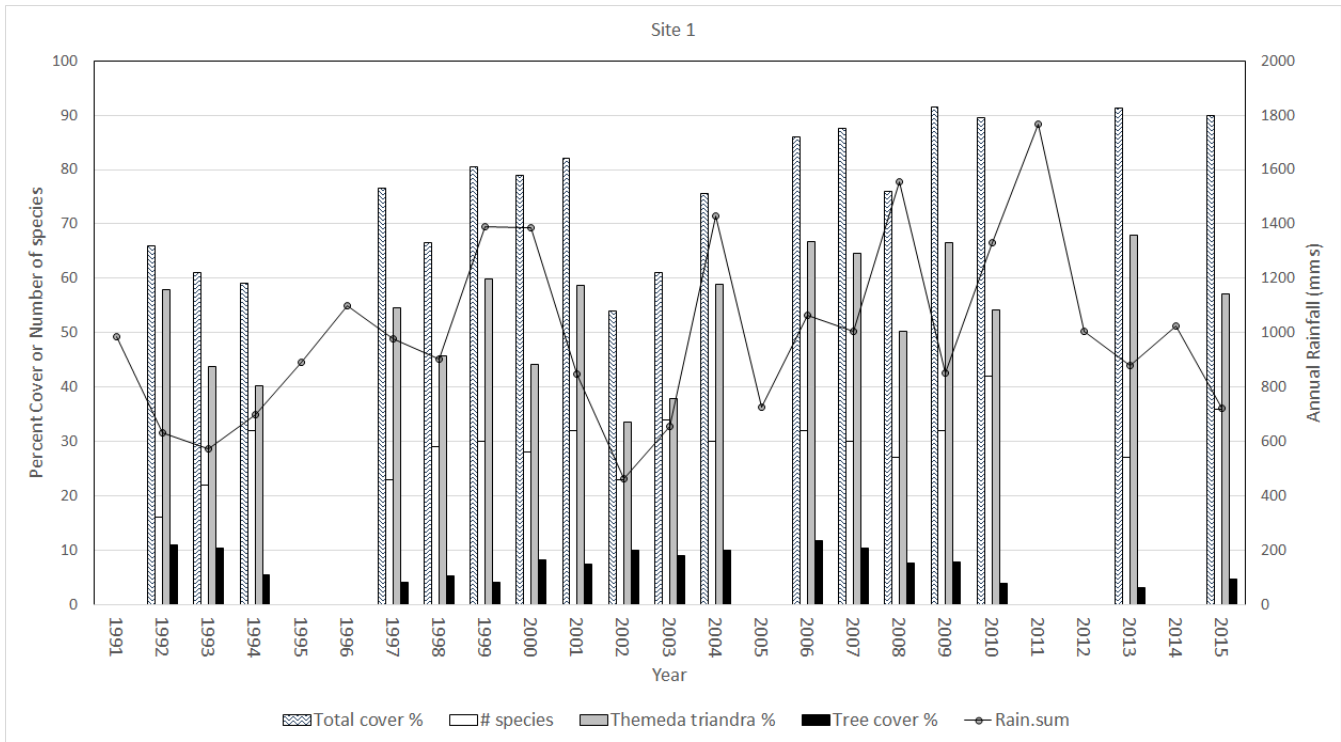


Fig. S4. Bar graphs of ground layer species richness and total cover, *Themeda triandra* cover and tree cover over the 23-year period for all five sites. The annual rainfall (mm) recorded in each year.

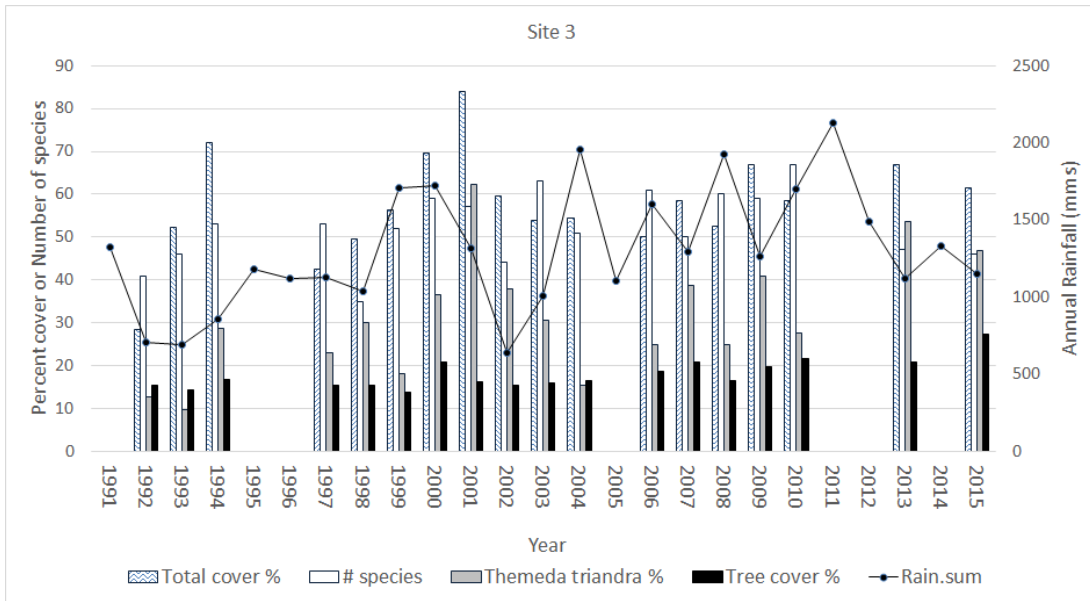
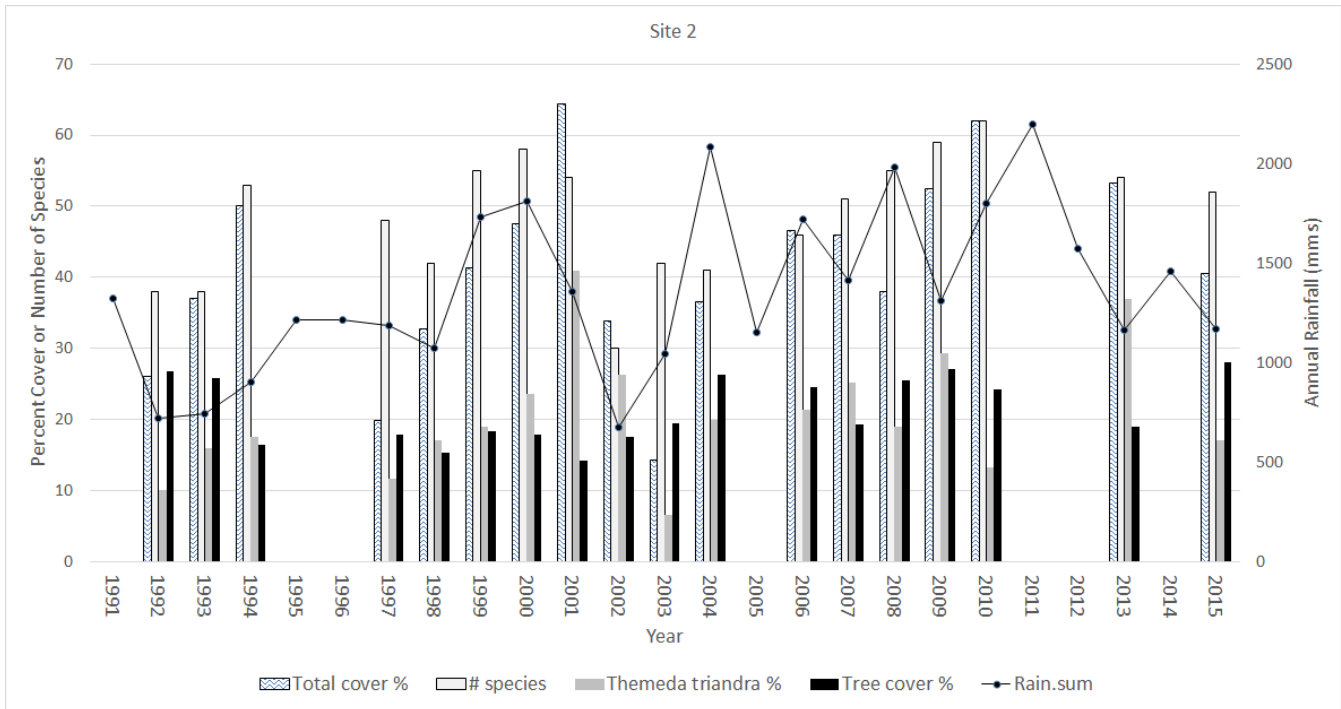


Fig. S4. (Cont.)

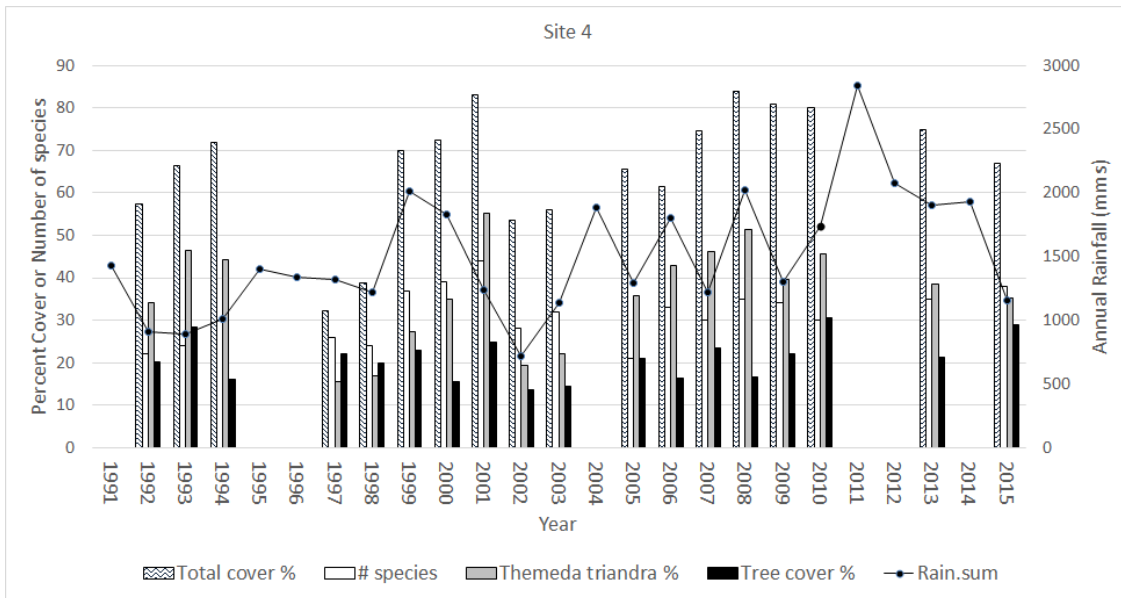


Fig. S4. (Cont.)

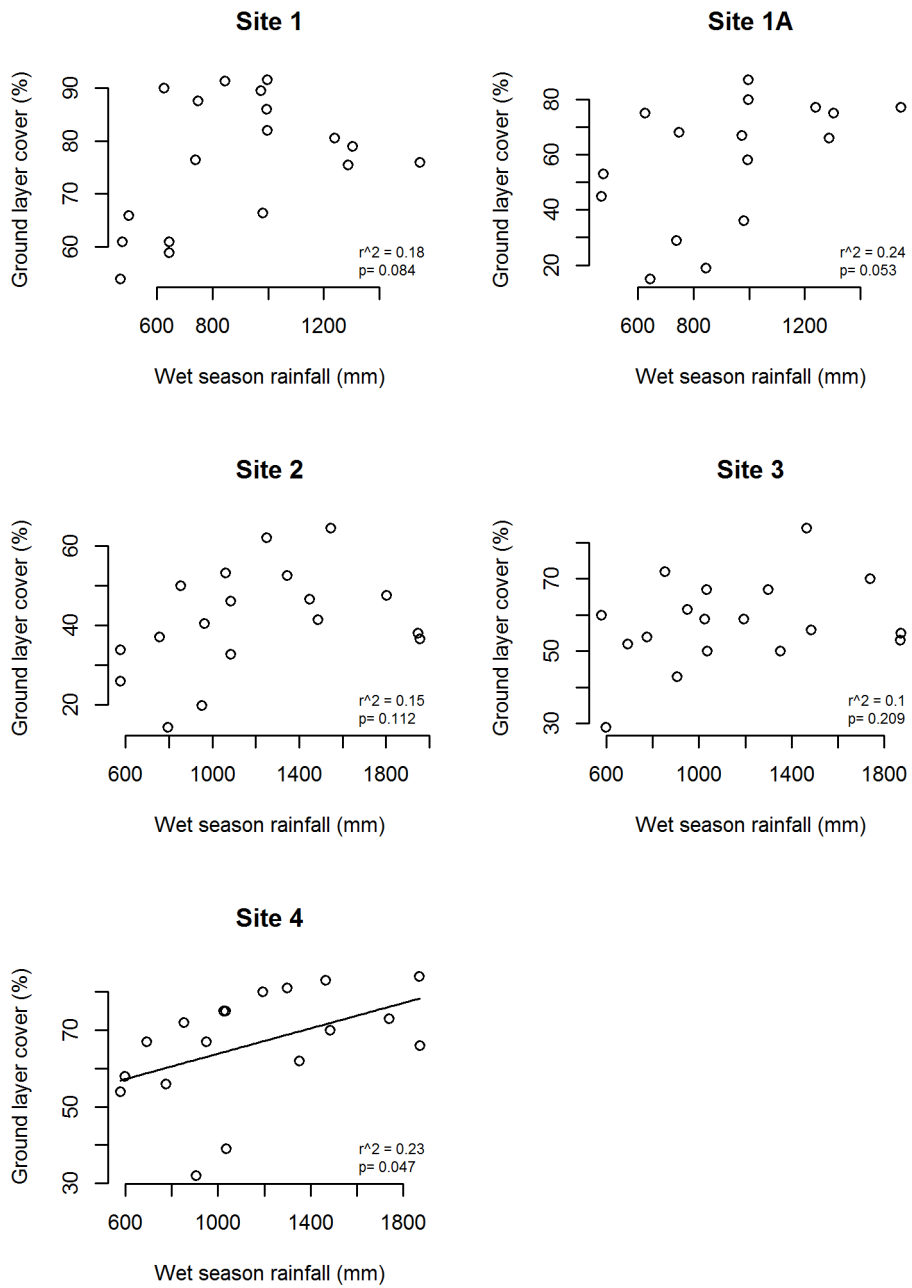


Fig. S5. Ground cover (%) compared with previous wet season rainfall for five sites over 23 years. Linear regression lines fitted to data where $P < 0.05$.

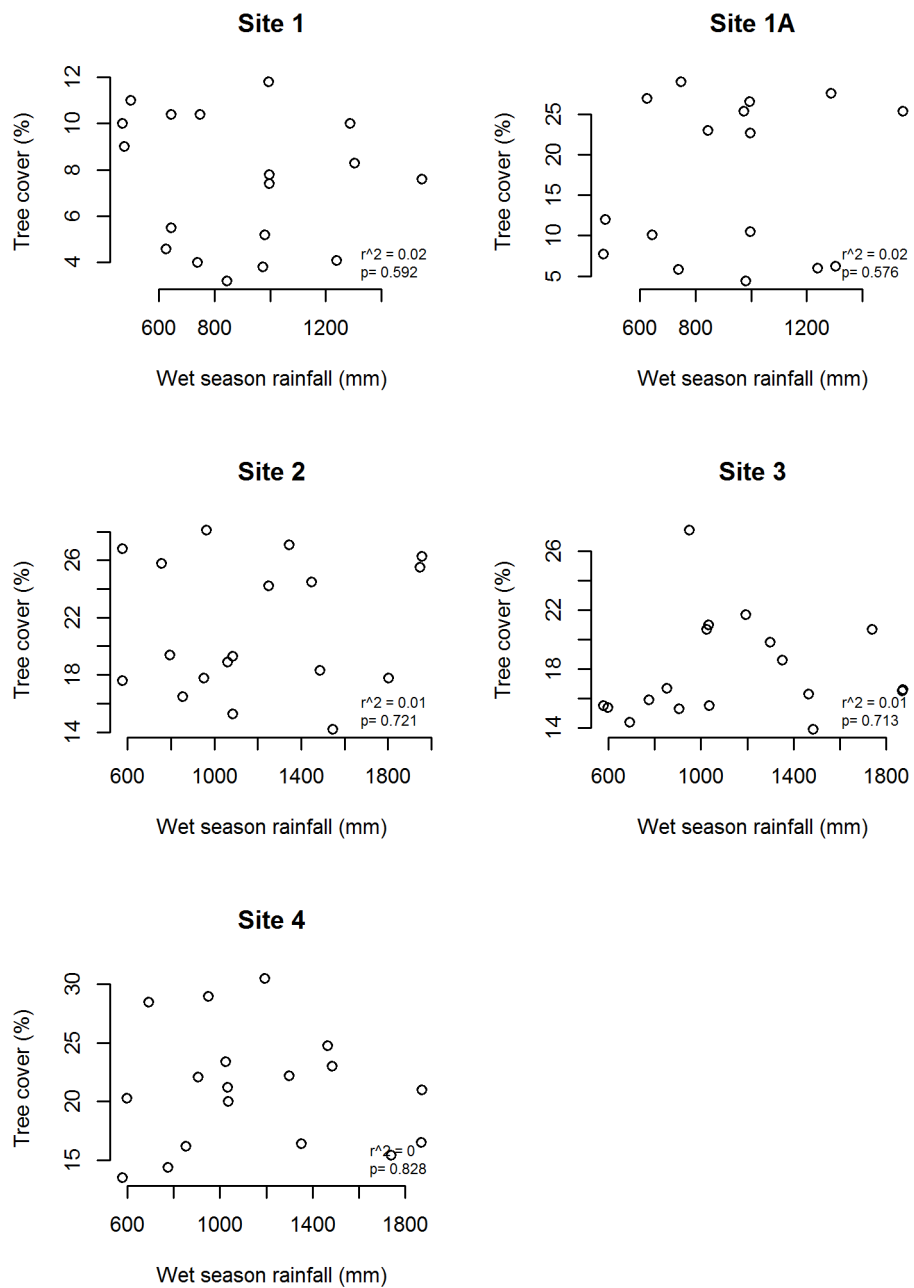


Fig. S6. Tree canopy cover (%) compared with previous wet season rainfall for five sites over 23 years. Linear regression lines fitted to data where $P < 0.05$.

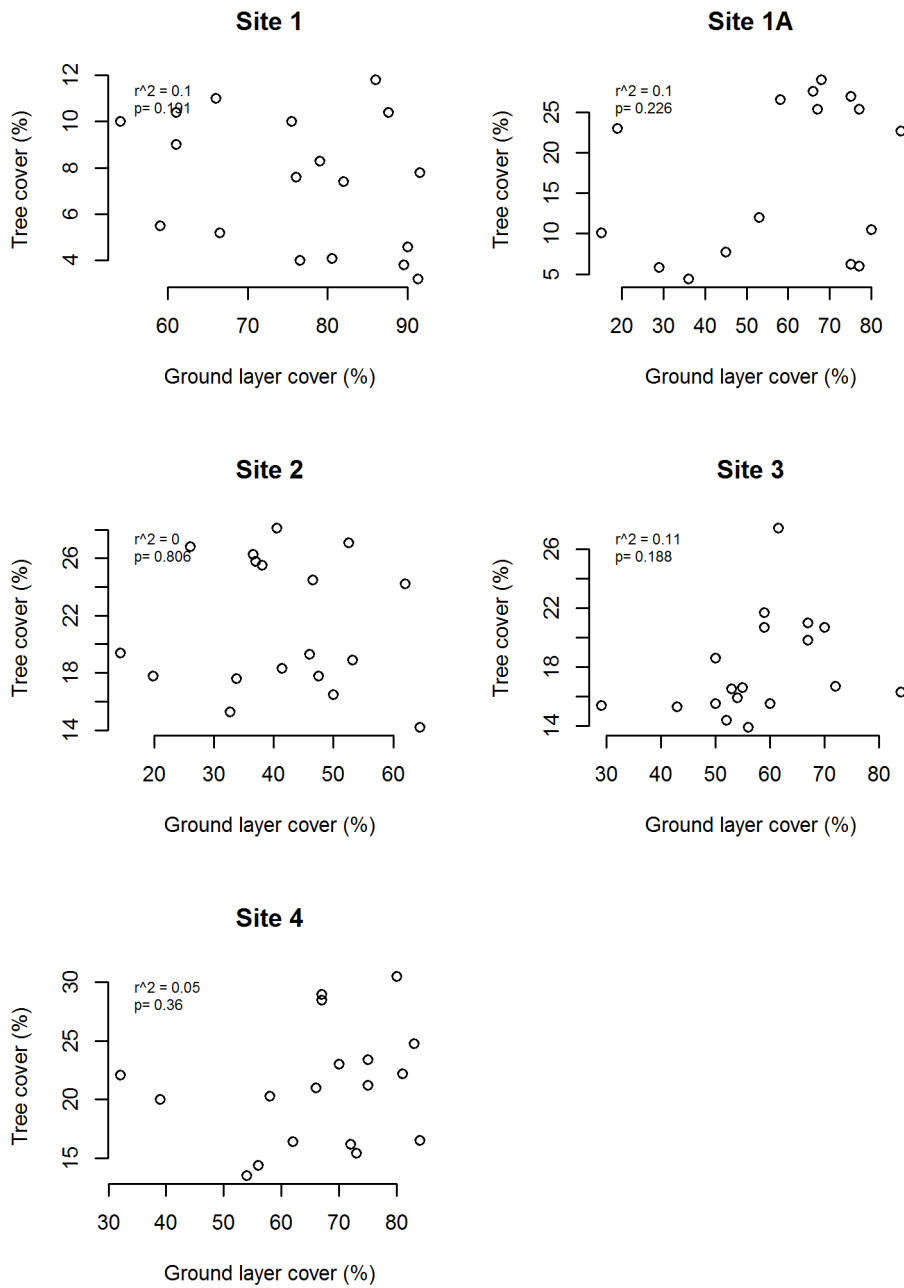


Fig. S7. Ground cover (%) compared with tree canopy cover for five sites over 23 years. Linear regression lines fitted to data where $P < 0.05$.

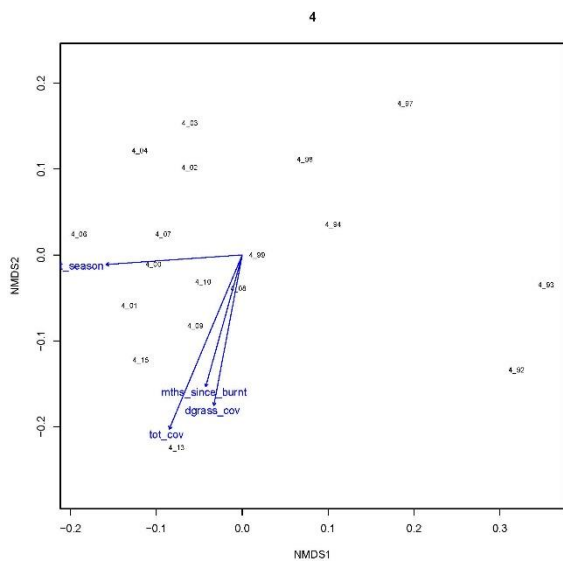
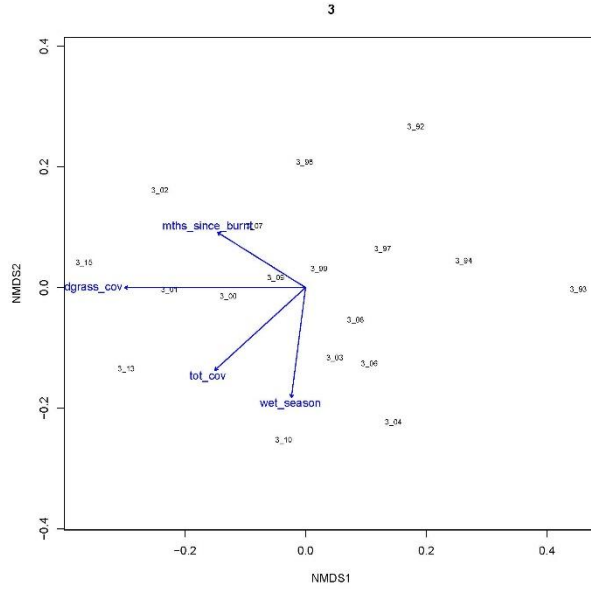
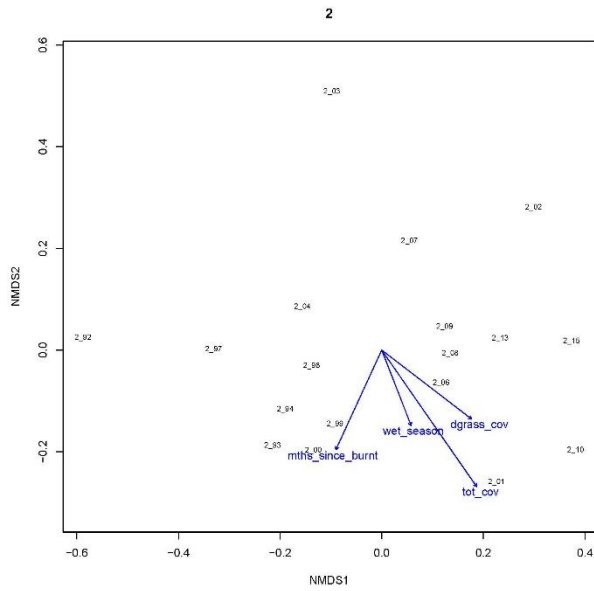
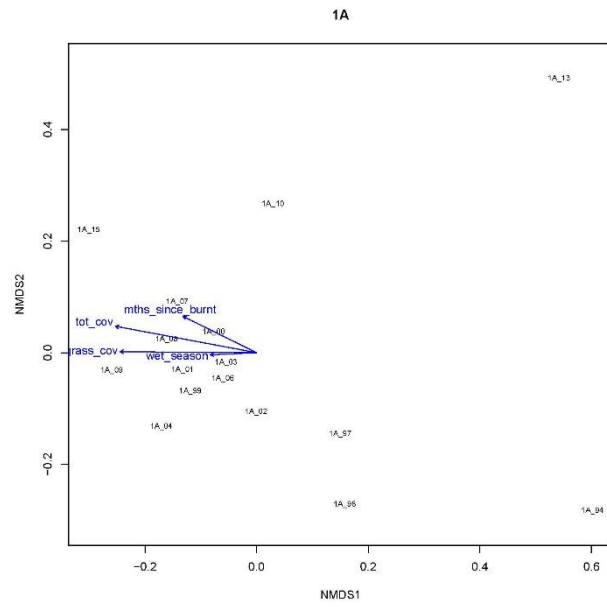
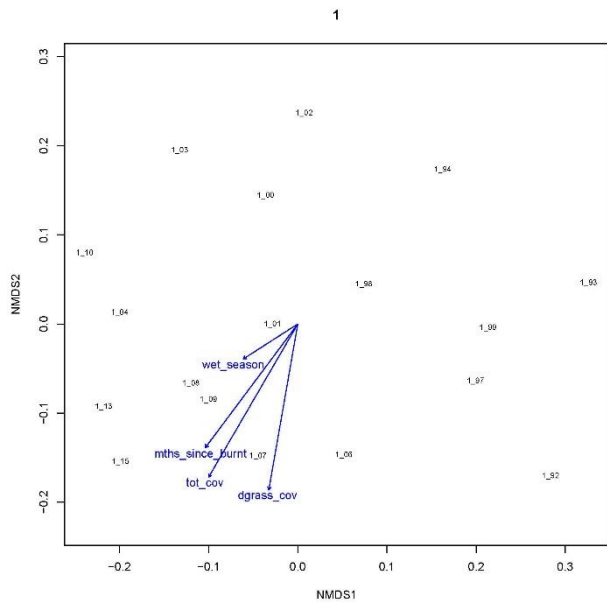


Fig. S8. Significant vectors through a two-dimensional ordination based on species composition data for each monitoring site (1, 1A, 2, 3, 4). The vectors are: Year, time of sampling; Wet_season, December to April rainfall before sampling; Mths_since_burnt, number of months since last fire at site; Tot_cove, total cover of ground layer species; and dgrass_cov, cover of the dominant grasses (*Themeda triandra* and *Heteropogon triticeus*).

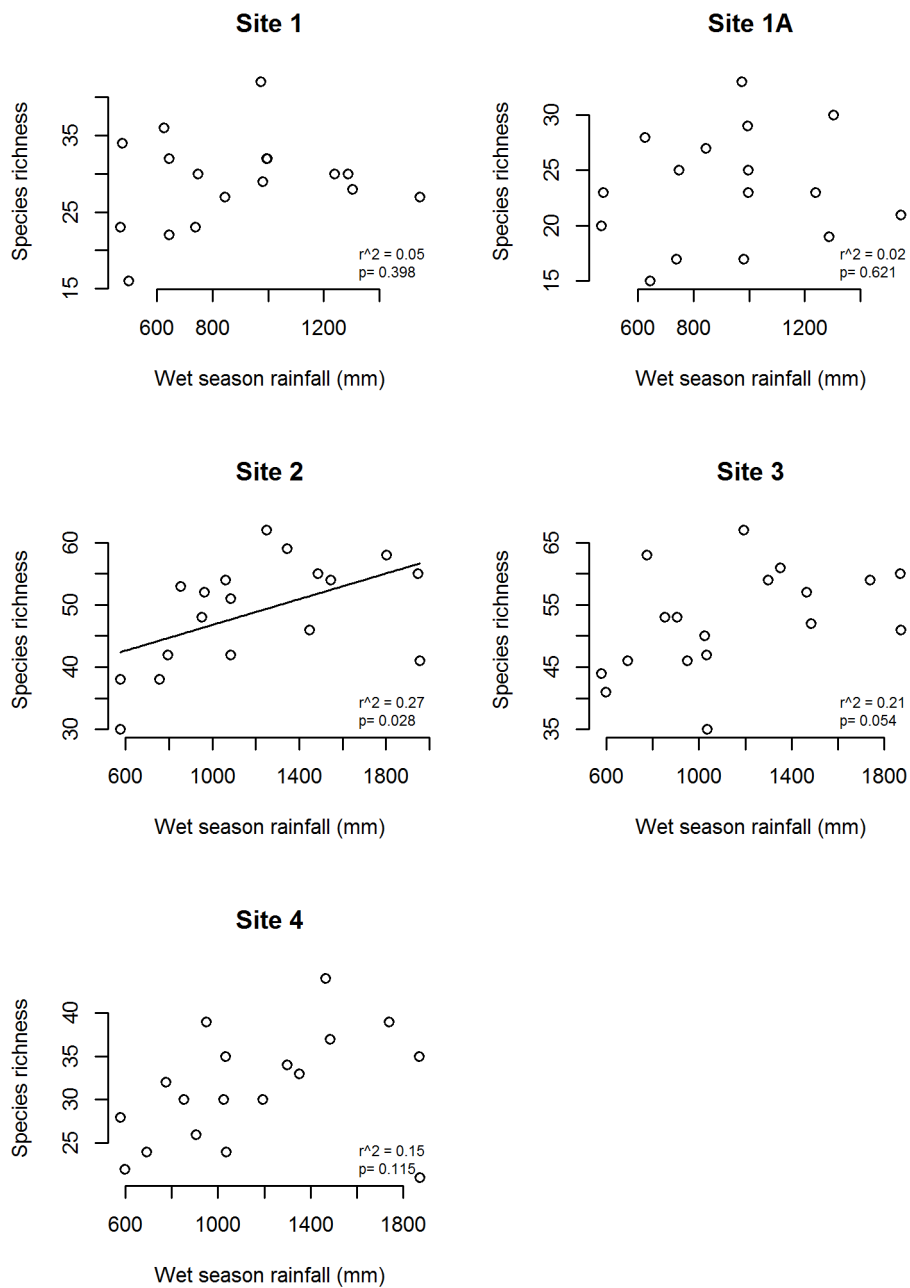


Fig. S9. Species richness compared with previous wet season rainfall for five sites over 23 years. Linear regression lines fitted to data where $P < 0.05$.

References

- Fox ID, Neldner VJ, Wilson GW, Bannink PJ (2001) 'The Vegetation of the Australian Tropical Savannas.' (Environmental Protection Agency: Brisbane, Qld, Australia)
- Jeffrey SJ, Carter JO, Moodie KB, Beswick AR (2001) Using spatial interpolation to construct a comprehensive archive of Australian climate data. *Environmental Modelling & Software* **16**, 309–330. [doi:10.1016/S1364-8152\(01\)00008-1](https://doi.org/10.1016/S1364-8152(01)00008-1)