

Supplementary Information

Long-term vegetation change (>20 years) in the plains habitat on the Goegap Nature Reserve, Succulent Karoo, South Africa

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Table S1: Significance (*p*-values) of relationship between perennial and annual plant cover and rainfall parameters

Transect	Perennial component			Annual component		
	Winter rainfall	Rainfall of 12-months prior to survey	Summer rainfall	Winter rainfall	Rainfall of 12-months prior to survey	Summer rainfall
Agterlos plains	0.2480	0.2928	0.6500	0.0002	0.0044	0.4176
Bleshoek plains	0.0202	0.0009	0.0201	0.0001	0.0156	0.9770
Droëdap River plains	0.1865	0.1892	0.4995	0.0081	0.0576	0.7126
Gugab plains	0.0696	0.0033	0.0437	0.0002	0.0003	0.2765
Jaagleegte plains	0.7913	0.1563	0.0591	0.0002	0.0158	0.9168

Significant correlations in bold

Table S2: R^2 - and *p*-values for regressions of the abundance of graminoid, nonsucculent shrubs and succulent shrubs over time (years)

	R^2 -value	<i>p</i> -value
Graminoids		
Bleshoek plains	0.6742	<0.0001 decrease
Gugab plains	0.1213	0.088
Jaagleegte plains	0.6247	Parabolic relationship
Nonsucculent shrubs		
Agterlos plains	0.2201	0.1435
Bleshoek plains	0.0702	0.2006
Droëdap River plains	0.0486	0.3372
Gugab plains	0.1092	0.0180 decrease
Jaagleegte plains	0.0086	0.6593
Succulent shrubs		
Agterlos plains	0.4172	0.0016 decrease
Bleshoek plains	0.0171	0.8442
Droëdap River plains	0.3140	0.0082 increase
Gugab plains	0.0144	0.5678
Jaagleegte plains	0.2492	0.1110

Significant correlations in bold

Table S3: Mean values for the diversity parameters over the monitored period. The *p*-values refer to the linear regression which was fit to the values over time (years)

	Species richness		Species evenness		Shannon-Wiener	
	Mean	p-value	Mean	p-value	Mean	p-value
Perennials						
Agterlos plains	3.3	0.3348	0.880	0.0242	1.044	0.8119
Bleshoek plains	10.3	<0.0001	0.929	0.9503	2.155	<0.0001
Droëdap River plains	8.4	0.7794	0.925	0.5062	1.960	0.9187
Gugab plains	11.0	0.1813	0.931	0.1915	2.205	0.0798
Jaagleegte plains	8.5	0.8307	0.887	0.2914	1.879	0.9495
Annuals						
Agterlos plains	18.4	0.3040	0.927	0.5816	2.625	0.1993
Bleshoek plains	19.7	0.4803	0.943	0.0242	2.696	0.7077
Droëdap River plains	8.3	0.6936	0.871	0.0133	1.711	0.5818
Gugab plains	16.9	0.8732	0.947	0.0292	2.585	0.8893
Jaagleegte plains	16.0	0.4893	0.899	0.3025	2.367	0.5759

Significant correlations in bold

Table S4: R^2 - and p -values for regressions of the rainfall of the 12 months preceding the survey, winter rainfall, summer rainfall and stocking density against diversity parameters

	Species richness		Species evenness		Shannon-Wiener	
	R^2 -value	p -value	R^2 -value	p -value	R^2 -value	p -value
Perennial component						
12-month rainfall						
Agterlos plains	0.1342	0.1024	0.0488	0.3361	0.1313	0.1064
Bleshoek plains	0.1653	0.0437	0.0395	0.3407	0.2358	0.0139
Droëdap River plains	0.2025	0.0407	0.4051	0.0019	0.3299	0.0065
Gugab plains	0.0055	0.7299	0.0257	0.4546	0.0024	0.8210
Jaagleegte plains	0.1540	0.0045	0.0163	0.3765	0.1441	0.0066
Winter rainfall						
Agterlos plains	0.0883	0.1907	0.0132	0.6198	0.0670	0.2572
Bleshoek plains	0.1393	0.0661	0.0386	0.3465	0.1930	0.0280
Droëdap River plains	0.0699	0.2468	0.5016	0.0003	0.1899	0.0483
Gugab plains	0.0538	0.2754	0.0029	0.8001	0.0653	0.2280
Jaagleegte plains	0.0063	0.7065	0.0245	0.4547	0.0116	0.6083
Summer rainfall						
Agterlos plains	0.0681	0.2532	0.4830	0.3385	0.0855	0.1985
Bleshoek plains	0.0528	0.2694	0.0096	0.6412	0.0790	0.1737
Droëdap River plains	0.1751	0.0591	0.0711	0.2426	0.1923	0.0467
Gugab plains	0.0174	0.5389	0.0299	0.4192	0.0372	0.2669
Jaagleegte plains	0.2592	0.0093	0.0010	0.8794	0.2122	0.0205
Stocking density						
Agterlos plains	0.1370	0.1081	0.0055	0.7500	0.1818	0.0608
Bleshoek plains	0.2270	0.0161	0.0695	0.2030	0.2981	0.0047
Droëdap River plains	0.3080	0.0090	0.2687	0.0161	0.4558	0.0008
Gugab plains	0.1502	0.0613	0.0004	0.9289	0.1264	0.0882
Jaagleegte plains	0.0314	0.3965	0.1502	0.0556	0.0651	0.2183
Annual component						
12-month rainfall						
Agterlos plains	0.0411	0.0283	0.0090	0.6831	0.1234	0.1183
Bleshoek plains	0.1997	0.0286	0.0066	0.7046	0.1294	0.0842
Droëdap River plains	0.3681	0.0035	0.1014	0.1594	0.3698	0.0034
Gugab plains	0.3269	0.0028	0.0004	0.9187	0.2600	0.0092
Jaagleegte plains	0.2159	0.0193	0.0143	0.5688	0.1951	0.0271
Winter rainfall						
Agterlos plains	0.1719	0.0617	0.0403	0.3829	0.0619	0.2769
Bleshoek plains	0.2995	0.0046	0.2104	0.0211	0.1408	0.0644
Droëdap River plains	0.5266	0.0002	0.1003	0.1620	0.4801	0.0005
Gugab plains	0.3650	0.0014	0.0081	0.6683	0.2376	0.0135
Jaagleegte plains	0.3709	0.0012	0.0202	0.4983	0.3085	0.0040
Summer rainfall						
Agterlos plains	0.1115	0.1391	0.0028	0.8191	0.0816	0.2095
Bleshoek plains	0.0208	0.4920	0.0567	0.2516	0.0284	0.4209
Droëdap River plains	0.0420	0.3727	0.0290	0.4608	0.0572	0.2967
Gugab plains	0.0390	0.3440	0.0038	0.7697	0.0524	0.2712
Jaagleegte plains	0.0058	0.7186	0.0012	0.8691	0.0093	0.6471
Stocking density						
Agterlos plains	0.0618	0.2772	0.0247	0.4812	0.0424	0.8420
Bleshoek plains	0.0935	0.1372	0.0871	0.1521	0.0776	0.1775
Droëdap River plains	0.1282	0.1110	0.0162	0.5528	0.1123	0.1375
Gugab plains	0.1415	0.0639	0.1418	0.0635	0.1139	0.0990
Jaagleegte plains	0.01697	0.0407	0.0491	0.2869	0.1131	0.1002

Significant correlations in bold

Table S5: R^2 - and p -values for regressions of range condition over time (years)

Transect	R^2	Relationship	p-value
Agterlos plains	0.0116	Linear	0.6424
Bleshoek plains	0.1058	Linear	0.1127
Droëdap River plains	0.1914	Linear (increase)	0.0473
Gugab plains	0.0011	Linear	0.8750
Jaagleegte plains	0.4428	Parabolic	-

Significant correlations in bold

Table S6: Species names and author citations used in the figures

Abbreviation	Species name and authority
Aizo can	Aizoon canariense L.
Apto ind	Aptosimum indivisum Burch. ex Benth.
Apto spi	Aptosimum spinescens (Thunb.) F.E.Weber
Arc fas	Arctotis fastuosa Jacq.
Atri lin	Atriplex lindleyi Moq. subsp. inflata (F.Muell.) Paul G.Wilson
Auge cap	Augea capensis Thunb.
Blep mac	Blepharis macra (Nees) Vollensen
Chei den	Cheiridopsis denticulata (Haw.) N.E.Br.
Cler pap	Cleretum papulosum (L.f.) N.E. Br.
Coni elo	Conicosia elongata (Haw.) N.E.Br.
Cras thu	Crassula thunbergiana Schult. subsp. minutiflora (Schönland & Baker f.) Toelken
Crot exi	Crotalaria excisa (Thunb.) Baker f. subsp. namaquensis Polhill
Crot hum	Crotalaria humilis Eckl. & Zeyh.
Dasi ten	Dasispermum capense (Lam.) Magee & B.E.vanWyk
Dias nam	Diascia namaquensis Hiern
Dide car	Didelta carnosa (L.f.) Aiton
Dimo pin	Dimorphotheca pinnata (Thunb.) Harv.
Dimo pol	Dimorphotheca polyptera DC.
Dimo sin	Dimorphotheca sinuata DC.
Disc spi	Dischisma spicatum (Thunb.) Choisy
Dros his	Drosanthemum hispidum (L.) Schwantes
Dros otz	Lampranthus otzenianus (Dinter) Friedrich
Dros sp.	Drosanthemum sp.
Erio mic	Eriocephalus microphyllus DC.
Erod cic	Erodium cicutarium (L.) L'Hér.
Euph dec	Euphorbia rhombifolia Boiss.
Feli nam	Felicia namaquana (Harv.) Merxm.
Fove dic	Foveolina dichotoma (DC.) Källersjö
Gale afr	Galenia africana L.
Gale sar	Galenia sarcophylla Fenzl
Gaza het	Gazania heterochaeta DC.
Gaza lic	Gazania lichtensteinii Less.
Gaza ten	Gazania tenuifolia Less.
Geo	Various geophytic species
Grie hum	Grielum humifusum Thunb.
Gymn lin	Gymnodiscus linearifolia DC.
Heli cor	Heliophila coronopifolia L.
Heli lac	Heliophila lactea Schltr.
Heli leo	Helichrysum leontonyx DC.
Heli obt	Helichrysum obtusum (S.Moore) Moeser
Heli ses	Heliophila seselifolia Burch. ex DC. var. seselifolia
Heli var	Heliophila variabilis Burch. ex DC.
Herm cun	Hermannia cuneifolia Jacq. var. cuneifolia
Herm dis	Hermannia disermifolia Jacq.
Herm gar	Hermannia gariepina Eckl. & Zeyh.
Hirp ech	Hirpicium echinus Less.
Hype sal	Kewa salsoloides (Burch.) Christenh.
Iflo glo	Ifloga polycnemoides Fenzl
Iflo par	Ifloga paronychioides (DC.) Fenzl
Lasi bra	Lasiospermum brachyglossum DC.
Lasi mic	Lasiopogon micropoides DC.
Less dif	Lessertia diffusa R.Br.
Less sp	Lessertia sp.
Leys ten	Leysera tenella DC.

Loto bra	Lotononis parviflora (P.J.Bergius) D.Dieter
Loto fal	Lotononis falcata (E.Mey.) Benth.
Lyc bos	Lycium bosciifolium Schinz
Lyci cin	Lycium cinereum Thunb.
Manu alt	Manulea altissima L.f.
Manu che	Manulea cheiranthus (L.) L.
Mese gue	Mesembryanthemum guerichianum Pax
Mese noc	Mesembryanthemum noctiflorum L. subsp. noctiflorum
Mese ocu	Mesembryanthemum oculatum N.E.Br.
Mons sal	Monsonia salmoniflora (Moffett) F.Albers
Onco gra	Oncosiphon grandiflorus (Thunb.) Källersjö
Onco suf	Oncosiphon suffruticosus (L.) Källersjö
Oste amp	Osteospermum amplexans (Harv.) Norl.
Oste hyo	Osteospermum hyoseroides (DC.) Norl.
Oste sin	Osteospermum sinuatum (DC.) Norl. var. <i>sinuatum</i>
Oxal spp	Oxalis spp.
Pela red	Pelargonium redactum Vorster
Pela sen	Pelargonium senecioides L'Hér.
Peli vir	Peliostomum virgatum E.Mey. ex Benth.
Pent air	Pentameris airoides Nees subsp. <i>airoides</i>
Phar cro	Pharnaceum croceum E.Mey. ex Fenzl
Phar cro	Pharnaceum dichotomum L.f.
Phyl col	Phyllopodium collinum (Hiern) Hilliard
Plan caf	Plantago cafra Decne.
Psil jun	Mesembryanthemum junceum Haw.
Psil sub	Mesembryanthemum subnodosum A.Berger
Pter sca	Pteronia scariosa L.f.
Rusc bre	Ruschia brevibracteata L.Bolus
Rusc rob	Ruschia robusta L.Bolus
Sals aph	Salsola aphylla L.f.
Sals kal	Salsola kali L.
Sals tub	Salsola tuberculata (Moq.) Fenzl
Schi sch	Schismus schismoides (Stapf ex Conert) Verboom & H. P. Linder
Sene are	Senecio arenarius Thunb.
Sene car	Senecio cardaminifolius DC.
Sene niv	Senecio niveus (Thunb.) Willd.
Stip bre	Stipagrostis brevifolia (Nees) De Winter
Stip cil	Stipagrostis ciliata (Desf.) De Winter var. capensis (Trin. & Rupr.) De Winter
Stip nam	Stipagrostis namaquensis (Nees) De Winter
Stip obt	Stipagrostis obtusa (Delile) Nees
Stip zey	Stipagrostis zeyheri (Nees) De Winter
Tetr fru	Tetragonia fruticosa L.
Tetr mic	Tetragonia echinata Aiton
Tetr ret	Tetraena retrofracta (Thunb.) Beier & Thulin
Trac bul	Trachyandra bulbinifolia (Dinter) Oberm.
Trac sp	Trachyandra sp.
Trib ter	Tribulus terrestris L.
Trib ter	Tribulus zeyheri Sond. subsp. zeyheri
Ursi cal	Ursinia calenduliflora (DC.) N.E.Br.
Wahl ann	Wahlenbergia annularis A.DC.
Wahl pro	Wahlenbergia prostrata A.DC.
Wahl thu	Wahlenbergia thunbergiana (H.Buek) Lammers
Zalu ben	Zaluzianskya benthamiana Walp.
Zalu ped	Manulea cheiranthus (L.) L.
Zalu ped	Zaluzianskya peduncularis (Benth.) Walp.
Zalu pus	Manulea pusilla E.Mey. ex Benth.

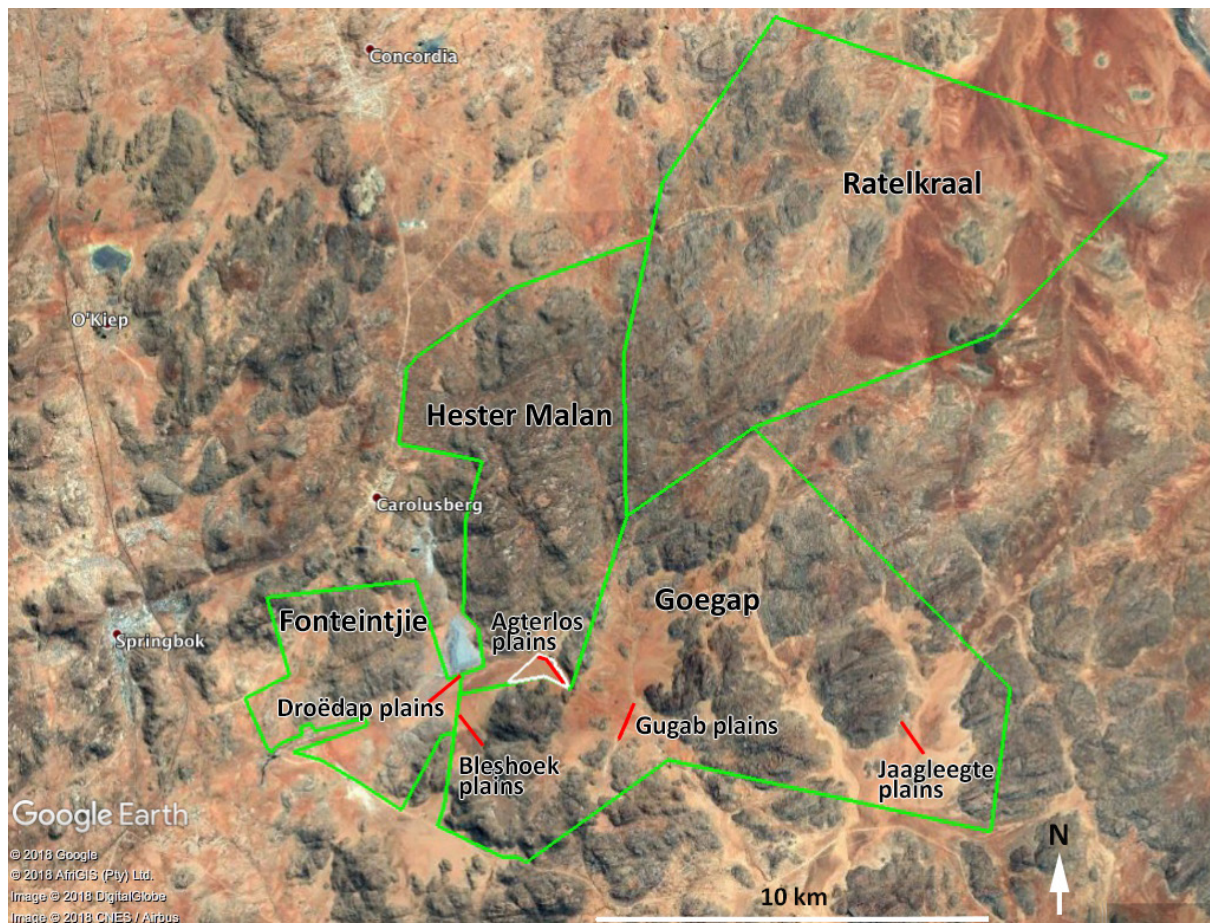


Figure S1: Location of the five transects in the Goegap Nature Reserve. The white polygon indicates the enclosure on Agterlos

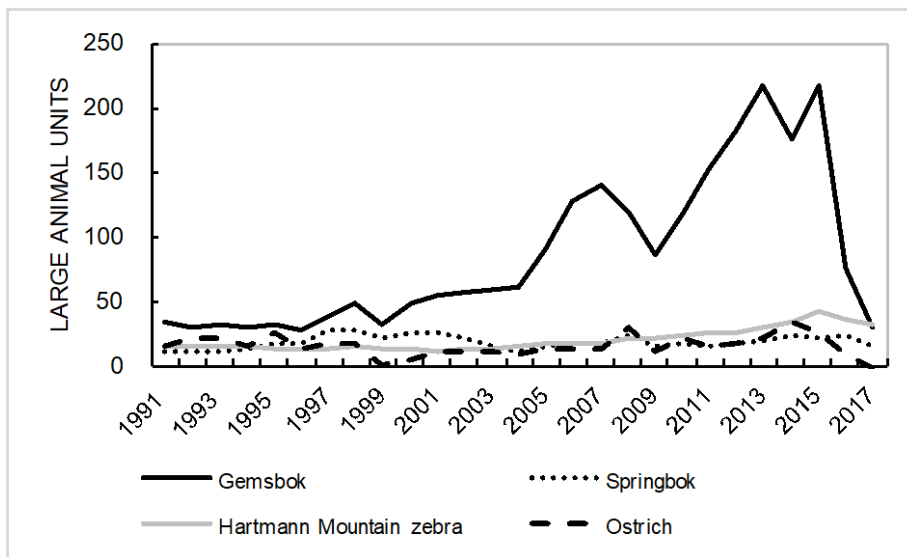


Figure S2: Gemsbok, springbok, Hartmann's mountain zebra and ostrich numbers (expressed as Large Animal Units) on the Goegap Nature Reserve

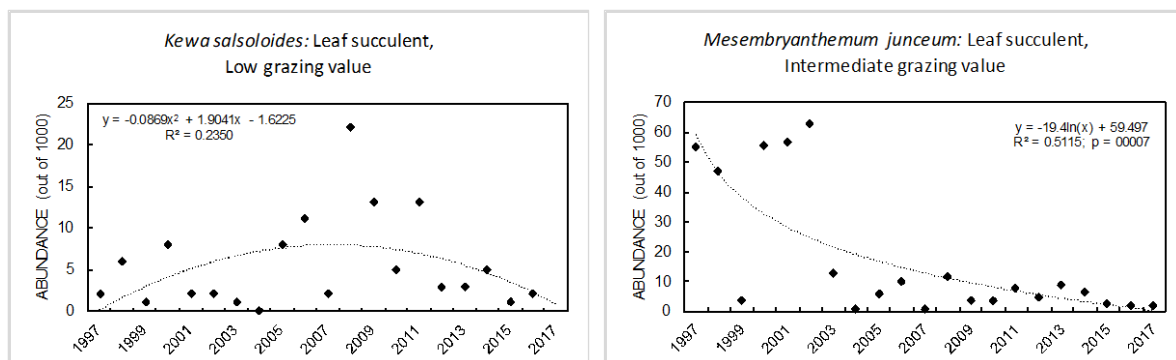


Figure S3: Changes in abundance (out of 1000) of most abundant species at the Agterlos plains ($n = 21$) transect over the 21-year monitoring period

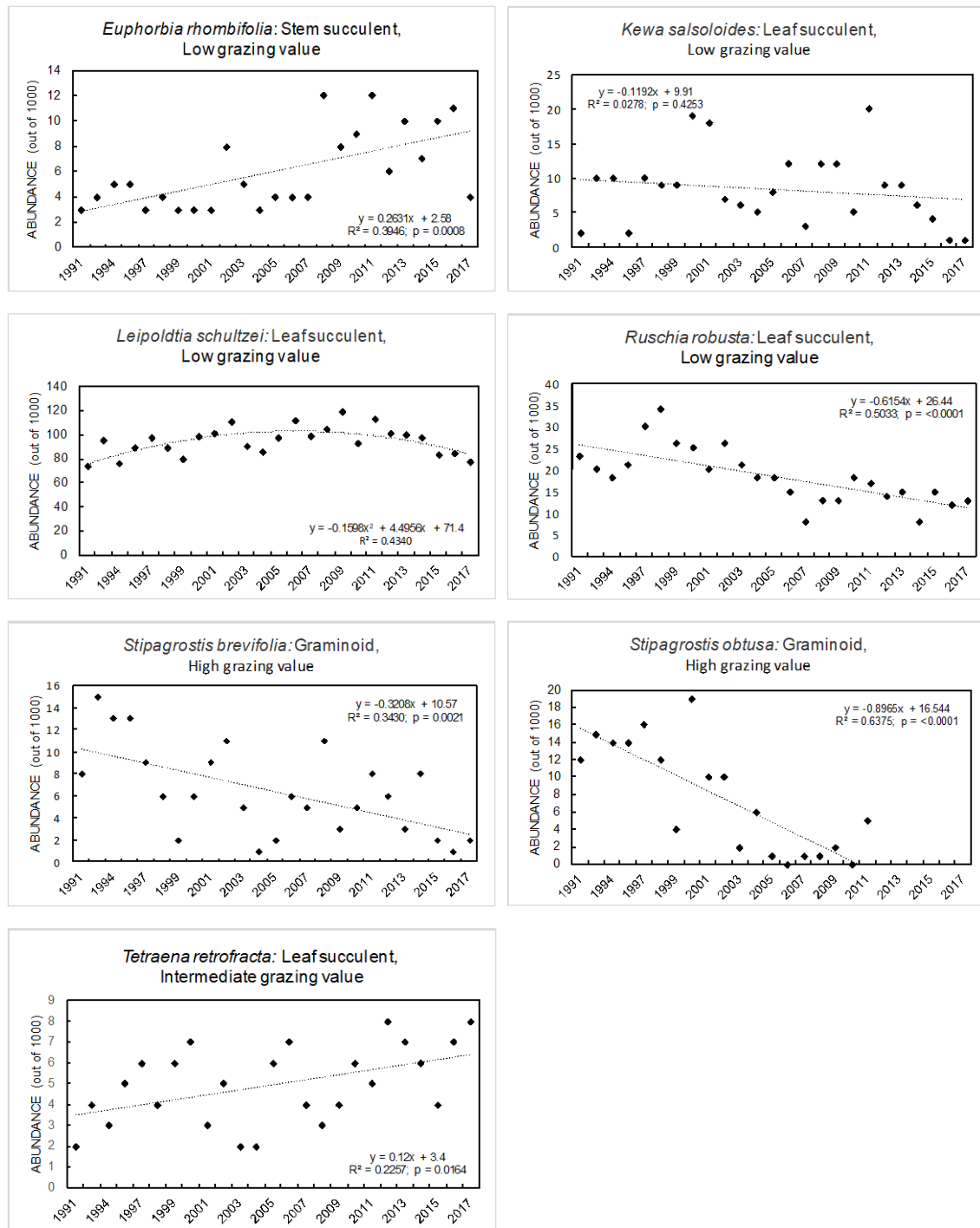


Figure S4: Changes in abundance (out of 1000) of most abundant species at the Bleshoek plains ($n = 25$) transect over the 27-year monitoring period

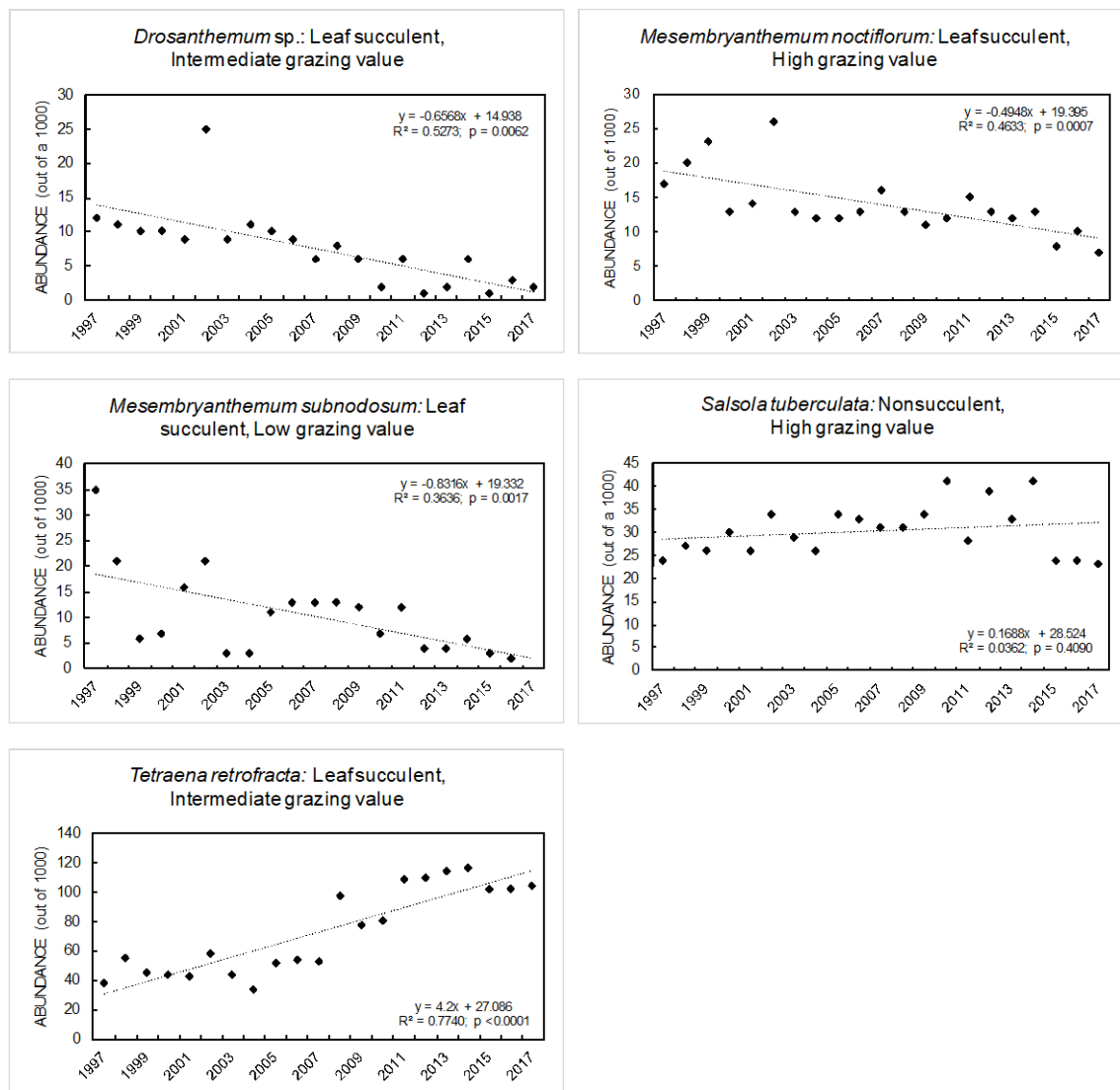


Figure S5: Changes in abundance (out of 1000) of most abundant species at the Droëdap River plains ($n = 21$) transect over the 21-year monitoring period

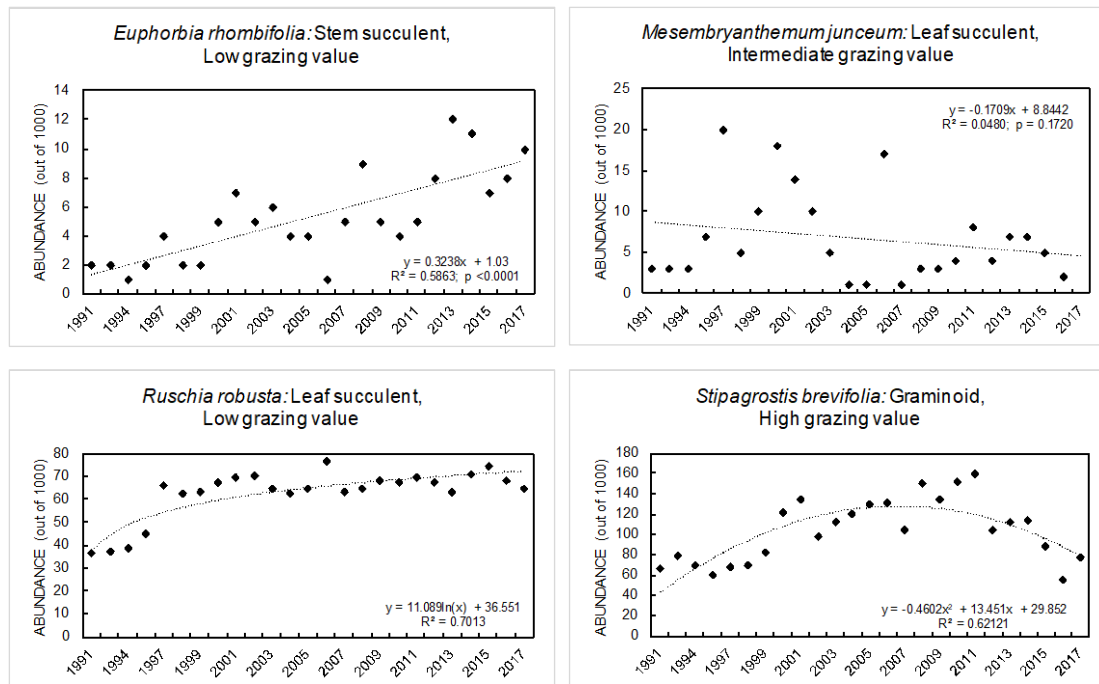


Figure S6: Changes in abundance (out of 1000) of most abundant species at the Jaagleege plains ($n = 25$) transect over the 27-year monitoring period

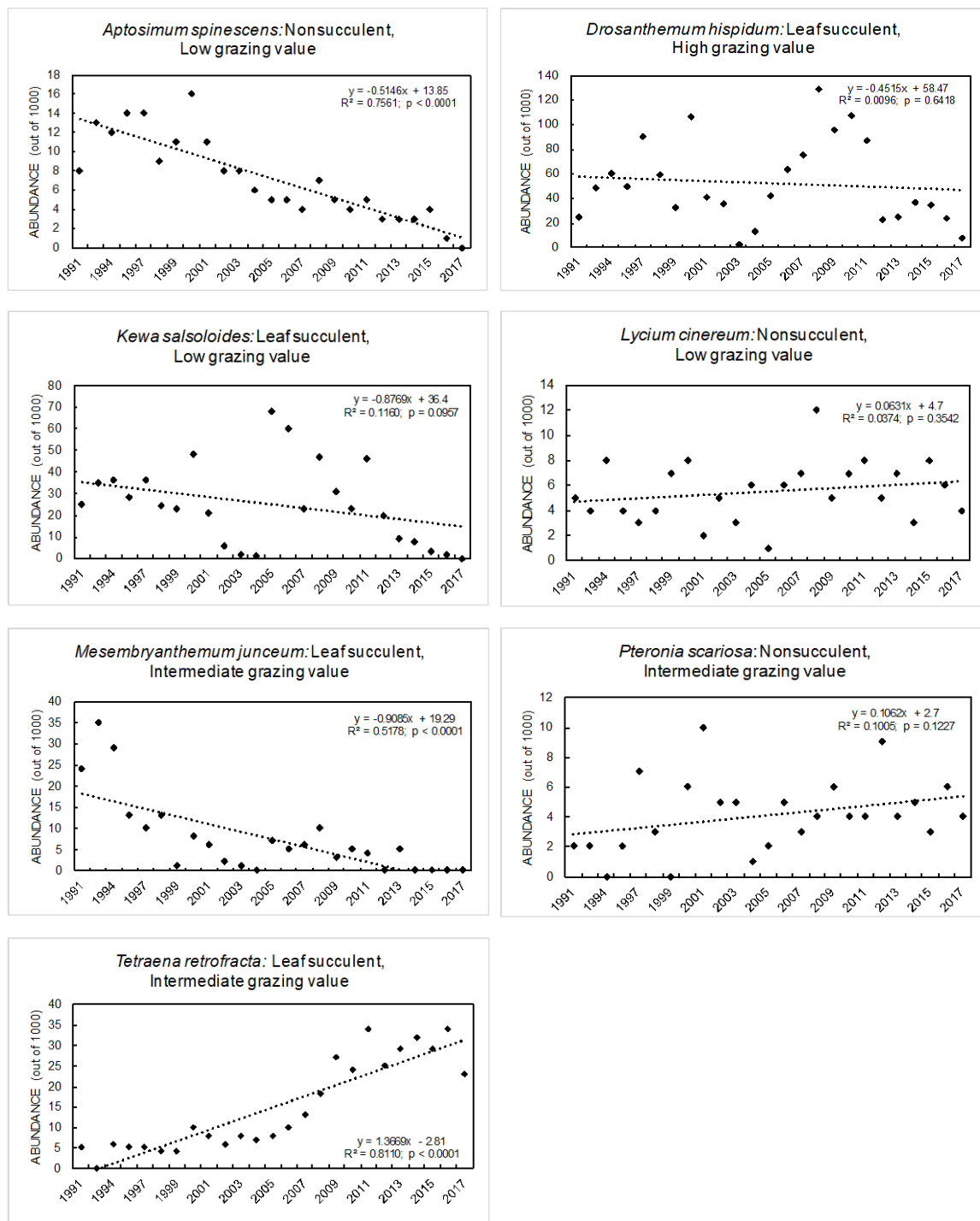
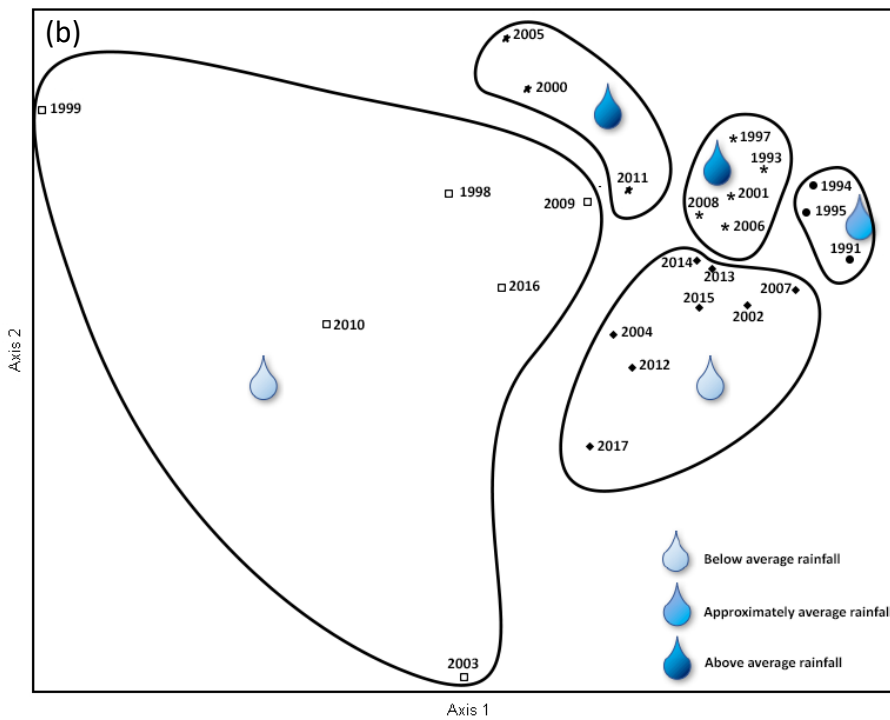
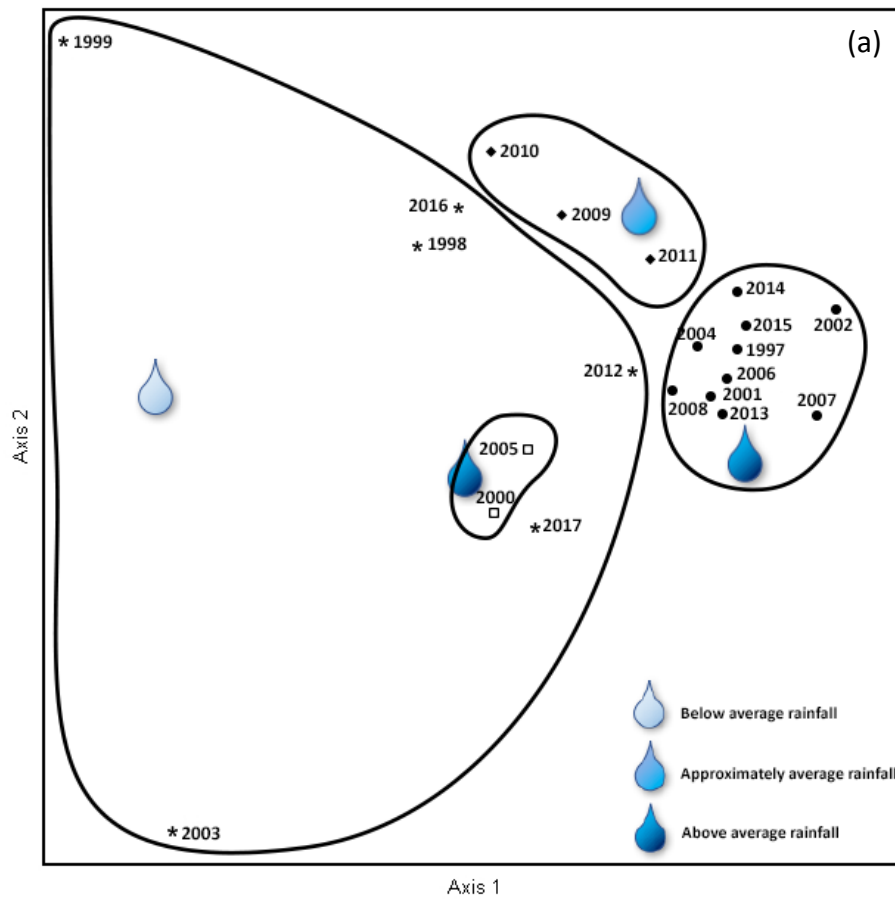
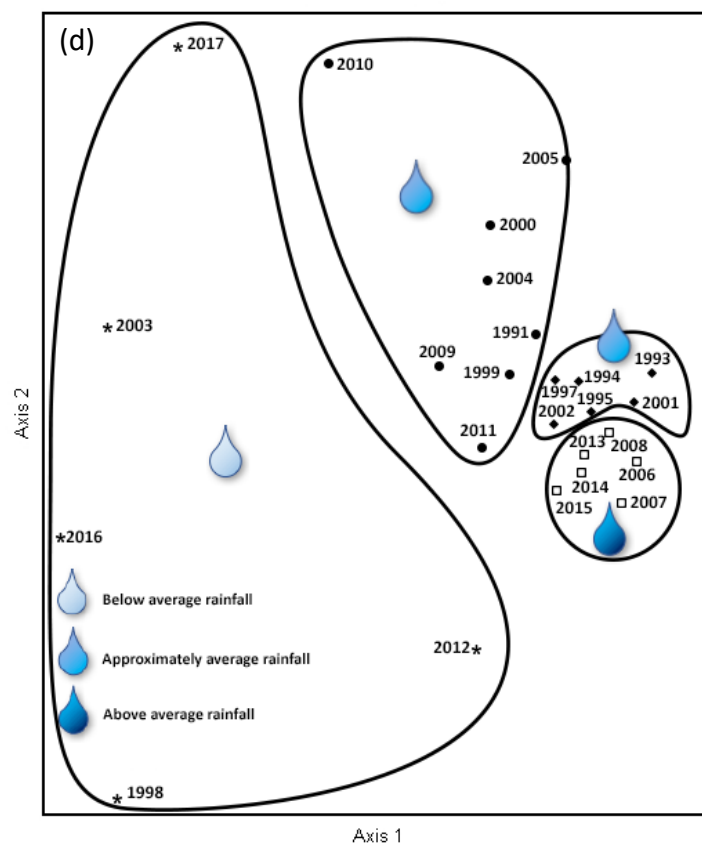
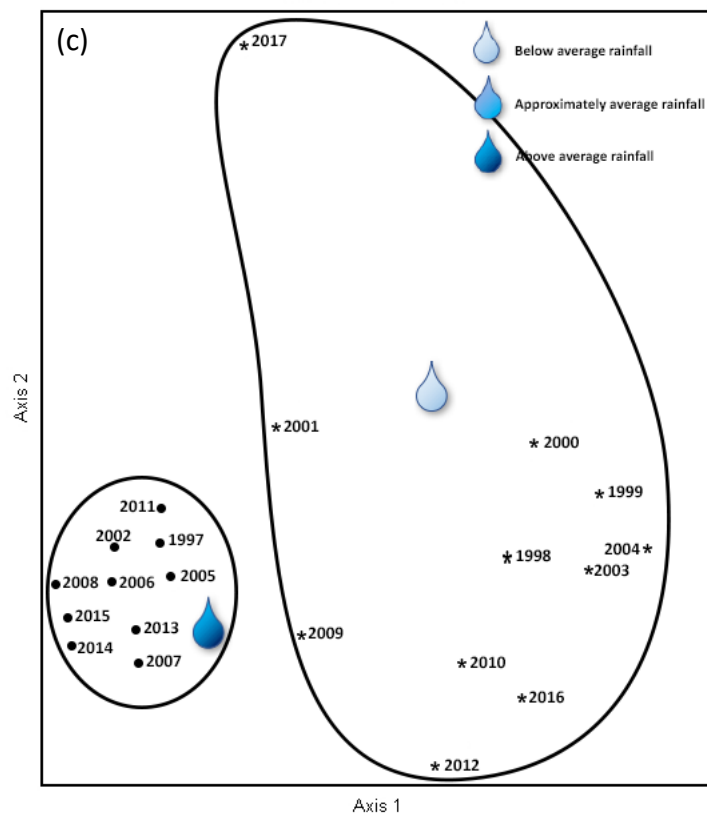


Figure S7: Changes in abundance (out of 1000) of most abundant species at the Gugab plains ($n = 21$) transect over the 27-year monitoring period





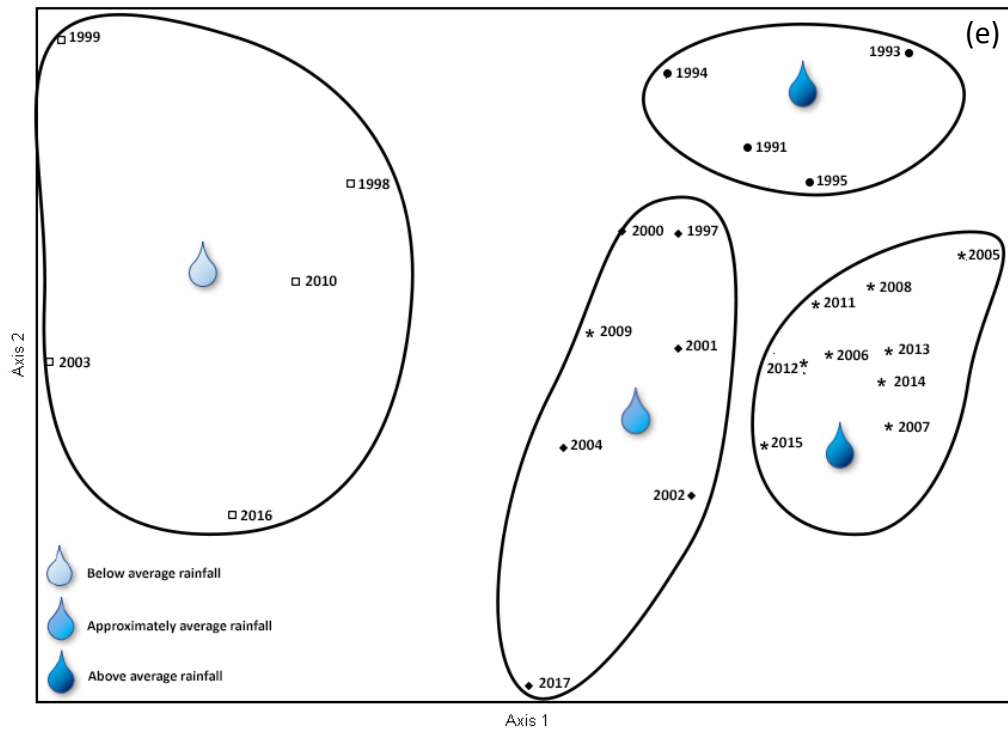
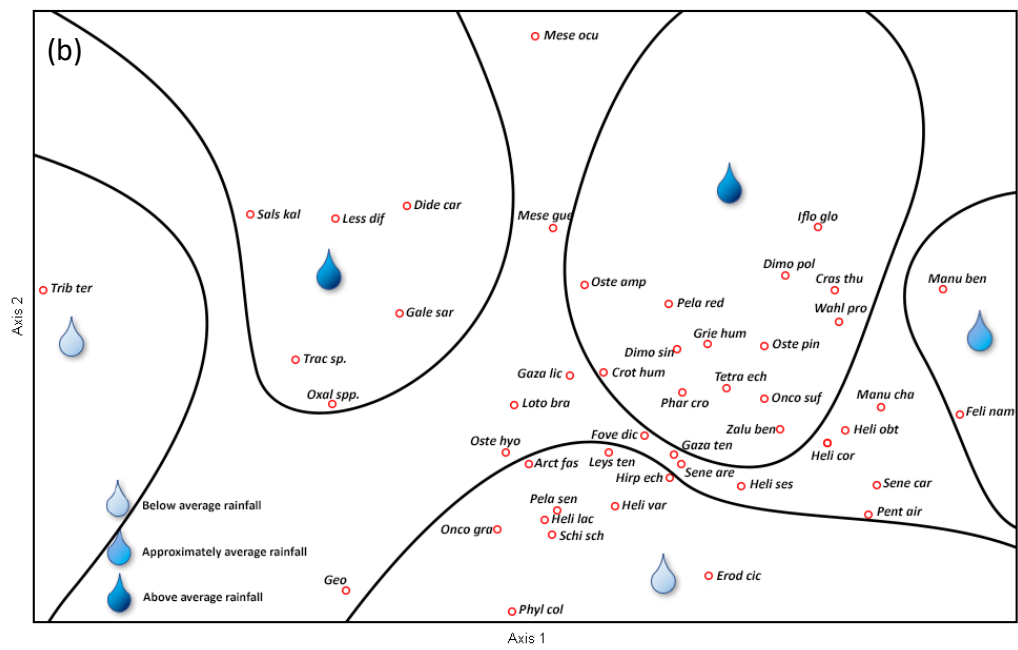
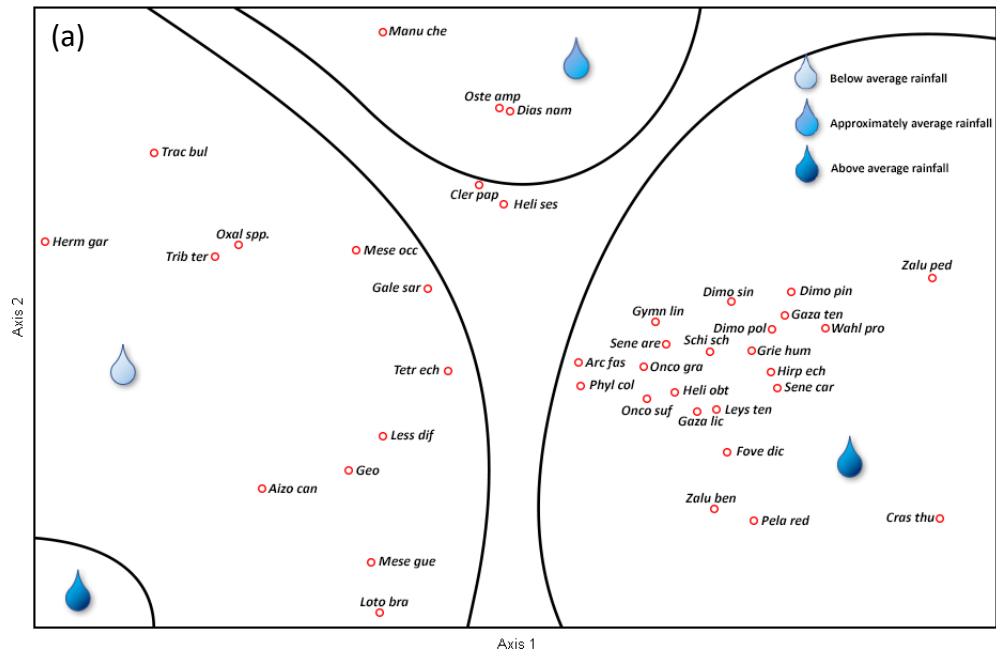
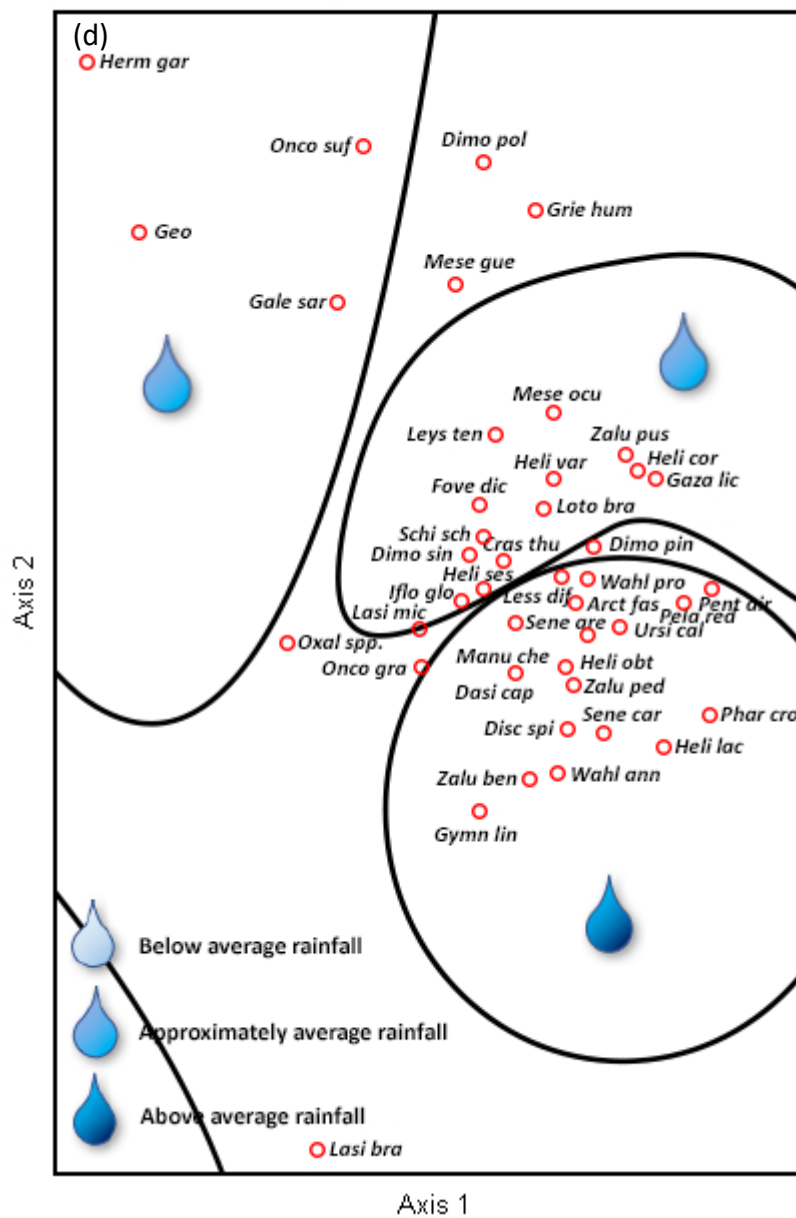


Figure S8: Non-metric multidimensional scaling scatter diagram of annual species' abundance data at five long-term monitoring sites (a) Agterlos ($n = 21$); (b) Bleshoek ($n = 25$); (c) Droëdap River plains ($n = 21$); (d) Jaagleegte ($n = 25$); and (e) Gugab ($n = 25$) in the Goegap Nature Reserve. Stress values: (a) 8.2; (b) 12.9; (c) 8.7; (d) 13.6; and (e) 11.0. The clusters of the years are based on the cluster analysis using Ward's algorithm. Coloured droplets roughly indicate the rainfall conditions in the cluster.





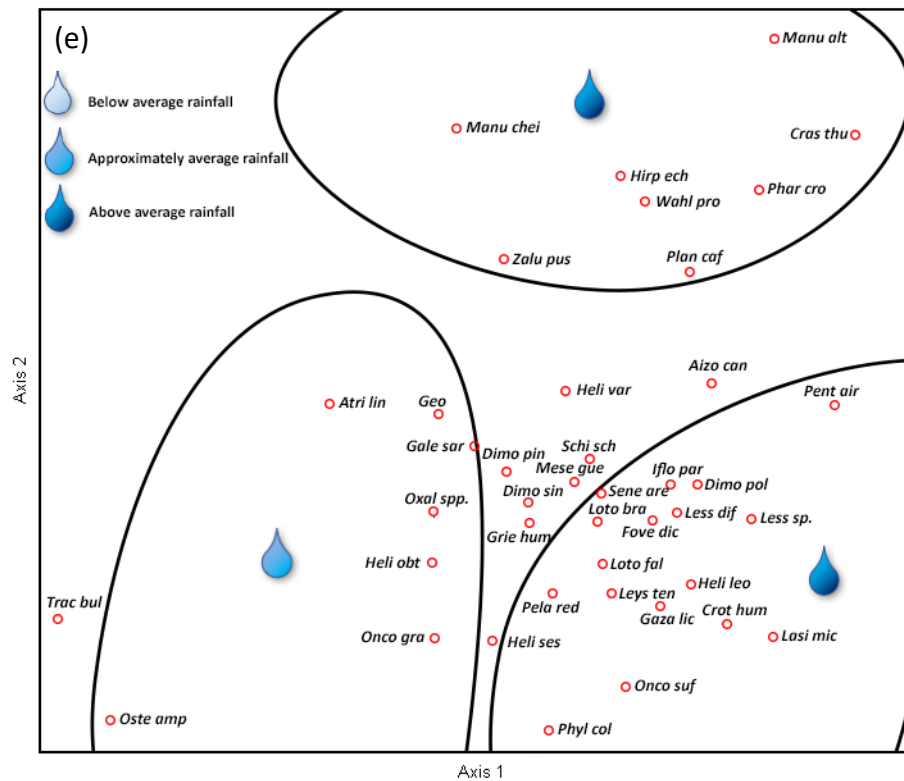


Figure S9: Non-metric multidimensional scaling scatter diagram of annual species' abundance data at five long-term monitoring sites (a) Agterlos ($n = 21$); (b) Bleshoek ($n = 25$); (c) Droëdap River plains ($n = 21$); (d) Jaagleegte ($n = 25$); and (e) Gugab ($n = 25$) in the Goegap Nature Reserve. Stress values: (a) 8.2; (b) 12.9; (c) 8.7; (d) 13.6; and (e) 11.0. The clusters of the years derived from the cluster analysis using Ward's algorithm is superimposed on the species data. Full species names are provided in Supplementary Table S6