

Contents

1	Introduction	1
1.1	General introduction	1
1.2	What creates a desert?	2
1.3	Deserts have low precipitation and high variability in precipitation	2
1.4	How old are deserts?	4
1.5	Deserts are created by a lack of precipitation and not high temperatures	6
1.6	Aridity indices	7
1.7	What denies rainfall to deserts?	9
1.8	Global change and deserts	12
2	Abiotic Factors	14
2.1	Precipitation	14
2.1.1	<i>Rainfall</i>	14
2.2	Temperature	23
2.2.1	<i>Hot deserts</i>	23
2.2.2	<i>Cold deserts</i>	23
2.3	Declines in pan evaporation	24
2.4	Geology	25
2.4.1	<i>Desert landscapes</i>	26
2.5	Fire	33
2.6	Wind erosion	34
3	Morphological and Physiological Adaptations of Desert Plants to the Abiotic Environment	36
3.1	Classifications of desert plants	36
3.2	Types of photosynthesis	40
3.3	Biological soil crusts	45
3.4	Annual plants	46
3.4.1	<i>Desert versus mesic annual species</i>	47
3.4.2	<i>Seed germination and dispersal strategies</i>	47
3.4.3	<i>Why is long-range dispersal rare in desert plants?</i>	50

3.4.4	<i>Delayed germination</i>	53
3.4.5	<i>Seed heteromorphism</i>	53
3.5	Grasses, forbs, and shrubs/perennials	55
3.5.1	<i>Clonality</i>	55
3.5.2	<i>Photosynthesis and stomatal opening</i>	55
3.5.3	<i>Heat shock proteins</i>	56
3.5.4	<i>Specific leaf area</i>	59
3.5.5	<i>Leaf pubescence</i>	59
3.5.6	<i>Fog—an unusual water source</i>	61
3.5.7	<i>Grasses</i>	61
3.6	Geophytes	62
3.6.1	<i>Hysteranthly and its consequences</i>	63
3.7	Stem and leaf succulents	63
3.7.1	<i>Stem succulents</i>	63
3.7.2	<i>Leaf succulents</i>	66
3.8	Halophytes	67
3.9	Phreatophytes	69
3.9.1	<i>Hydraulic lift</i>	70
4	Morphological, Physiological, and Behavioural Adaptations of Desert Animals to the Abiotic Environment	75
4.1	Evaders and evaporators	77
4.1.1	<i>Snails</i>	81
4.1.2	<i>Frogs</i>	83
4.1.3	<i>Rodents</i>	84
4.1.4	<i>Spider burrows and termite mounds</i>	87
4.1.5	<i>Physiological mechanisms of controlling heat gain</i>	88
4.2	Adaptations to handle unique situations	94
4.2.1	<i>Salt glands in birds and reptiles</i>	94
4.2.2	<i>Mammals that consume halophytes</i>	94
4.2.3	<i>Animals in temporary pools</i>	96
4.3	Endurers	97
4.3.1	<i>Ants</i>	97
4.3.2	<i>Large mammals</i>	98
4.4	Removing the effects of phylogeny	102
4.4.1	<i>Insects (tenebrionid beetles)</i>	102
4.4.2	<i>Birds</i>	106
4.4.3	<i>Marsupial mammals</i>	107
5	The Role of Competition and Facilitation in Structuring Desert Communities	109
5.1	Plant communities	109
5.1.1	<i>Annual plant communities</i>	110

5.1.2	<i>Interactions among desert shrubs</i>	111
5.1.3	<i>Fairy circles, heuweltjies, and mima mounds—competition, herbivory, or self-organization?</i>	113
5.1.4	<i>Facilitation and nurse-plant effects</i>	117
5.2	Competition between animals	122
5.2.1	<i>Patch scale</i>	122
5.2.2	<i>Habitat selection models</i>	123
5.3	Indirect interactions: keystone species and apparent competition	125
5.3.1	<i>Keystone species</i>	125
5.3.2	<i>Short-term apparent competition</i>	126
6	The Importance of Predation and Parasitism	128
6.1	Direct mortality	128
6.2	Predation risk	130
6.3	Apparent predation risk	133
6.4	Priority effects	135
6.5	Spiders	135
6.6	Scorpions	137
6.7	Visually hunting predators	138
6.8	Snakes, scent-hunting predators	140
6.9	Keystone predation	141
6.10	Animal parasites and parasitoids	143
6.10.1	<i>Parasites</i>	144
6.10.2	<i>Parasitoids</i>	145
7	Plant-Animal Interactions in Deserts	147
7.1	Herbivory	147
7.1.1	<i>Grazing effects on species composition</i>	150
7.1.2	<i>Long-term studies of the effects of large mammals on arid vegetation</i>	150
7.1.3	<i>Effects of herbivory on relationships among plant functional types</i>	151
7.1.4	<i>Is Australia a special case?—a meta-analysis</i>	157
7.1.5	<i>Effects of insect herbivory on desert plants</i>	159
7.2	Pollination	162
7.2.1	<i>Yucca-yucca moth mutualism</i>	164
7.2.2	<i>The senita cactus-senita moth obligate mutualism</i>	167
7.3	Seed dispersal and seed predation	169
7.3.1	<i>Myrmecochory</i>	171
7.3.2	<i>Diplochory: using two mechanisms to disperse</i>	173
7.4	Are these coevolved systems?	174
7.4.1	<i>Senita and yucca systems</i>	174
7.4.2	<i>Why Negev flowers are often red</i>	175
7.4.3	<i>Dorcas gazelle-lily system</i>	175
7.4.4	<i>Wood rats and their toxic diets</i>	178

8	Desert Food Webs and Ecosystem Ecology	180
8.1	Do deserts have simple food webs?	180
8.1.1	<i>Can we scale up from two-species interactions to desert ecosystems?</i>	182
8.2	Food webs	183
8.2.1	<i>Polis and Ayal's problems with food-web models</i>	185
8.3	Interactions among habitats—spatial subsidies	186
8.4	Effects of precipitation, nutrients, disturbances, and decomposition	188
8.4.1	<i>Effects of precipitation</i>	188
8.4.2	<i>Effects of nutrients</i>	194
8.4.3	<i>Disturbances</i>	198
8.4.4	<i>Decomposition</i>	199
9	Biodiversity and Biogeography of Deserts	204
9.1	Are deserts species-poor? α , β , and γ diversity patterns	204
9.1.1	<i>Plants</i>	204
9.1.2	<i>Animals</i>	206
9.2	Productivity–diversity relationships in deserts	212
9.3	Convergence and divergence of desert communities	213
9.3.1	<i>Community-wide character displacement</i>	218
9.4	Large-scale patterns in desert biogeography	222
9.4.1	<i>Plants</i>	223
9.4.2	<i>Animals</i>	231
10	Human Impacts and Desertification	235
10.1	The sensitive desert ecosystem: myth or reality?	235
10.2	Pastoralism is the most important use of desert lands	242
10.2.1	<i>Oscillations of vegetation and herbivore populations</i>	248
10.2.2	<i>Woody plant encroachment</i>	249
10.2.3	<i>Invasive species</i>	250
10.2.4	<i>Global climate changes</i>	251
10.3	Pumping aquifers: a problem of less water and more salinity	256
10.4	When is it desertification? The importance of reversibility	259
11	Conservation of Deserts	261
11.1	Are deserts worth conserving?	261
11.2	Conservation of desert species or habitats	261
11.2.1	<i>Umbrella species</i>	262
11.2.2	<i>Keystone species</i>	264
11.2.3	<i>Focal species</i>	264
11.2.4	<i>Single populations</i>	265
11.2.5	<i>SLOSS or metapopulations</i>	268
11.2.6	<i>Conserving the entire habitat</i>	270

11.3 The 3 Rs: reintroduction, recolonization, and revegetation	271
11.3.1 <i>Asiatic wild ass</i>	272
11.3.2 <i>Arabian oryx</i>	274
11.3.3 <i>Recolonization by the American black bear</i>	276
11.3.4 <i>Revegetation</i>	276
11.4 Genotype by environment interactions and intraspecific variability	277
11.5 Who gets to pay for this conservation and how is it controlled?	280
11.6 People are also part of the desert environment	280
11.7 Conclusions	282
References	283
Index	345