

Contents

Preface	xiii	1.5 Conclusions	26
Acknowledgements	xiv	1.6 Practical considerations	26
General introduction	1	1.7 Further reading	26
A focus on the Australian environment	1	2 What should be conserved?	27
Structure of the book	3	2.0 Introduction	27
Part I: Principles for conservation	5	2.1 Units of conservation	27
The multifaceted nature of conservation		Genetic diversity	28
biology	5	Populations	30
Soulé's conservation biology principles	5	The species concept	32
The tension between 'pure' and 'applied'		2.2 Number of species	36
conservation biology	5	Total number of species	37
1 Why conserve?	7	New habitats and new species	39
1.1 Introduction	7	Sampling methods and new species	40
Objectives of conservation	7	Rates of description of new species	40
Temporal changes in philosophies and		Summary: number of species	41
opinions	8	2.3 Species richness	41
1.1 Utilitarian value	8	Problems with the uncritical use of species	
Consumptive use value	9	richness	42
Productive use value	10	2.4 Endemism	42
Ecosystem service value	12	Causes of endemism	42
Scientific and educational value	14	Megadiverse nations and	
Cultural, spiritual, experiential and		endemism	43
existence value	16	Endemism and global biodiversity	
Aesthetic, recreational and tourist use	17	hotspots	43
Impacts of tourism on biodiversity	18	Endemism within Australia	44
Summary: utilitarian values	20	2.5 Species diversity: alpha, beta and gamma	
1.2 Intrinsic value	20	diversity	45
Ecocentric ethic	21	2.6 Vegetation structure as a target for	
Biocentric ethic	21	conservation	47
1.3 Anthropocentric bias	23	Australian rainforest	47
1.4 Custodial responsibility and the		Old growth forest	50
precautionary principle	24	2.7 Conclusions	55

- 2.8 Practical considerations 55
- 2.9 Further reading 56
- 3 Conservation status: classification of threat 57**
- 3.0 Introduction 57
- 3.1 Rarity and conservation status 57
 - Components of rarity 57
 - Rarity and conservation priorities 58
 - Relationships between components of rarity 59
 - Realised niches and rarity 59
 - Species abundance curve 60
 - Explanations for the species curve 60
 - Quantifying abundance, range and specificity 62
 - Ecological correlates of rarity 65
 - Rarity, threat and extinction proneness 65
- 3.2 Assessing conservation status 68
 - Extinct and presumed extinct species 68
 - Qualitative procedures for assessing threat 70
 - Rule sets 74
 - Point-scoring procedures 76
 - Uncertainty in conservation status assessment 76
 - Summary: assessing threat 79
- 3.3 Threatening processes 82
- 3.4 Conclusions 84
- 3.5 Practical considerations 85
- 3.6 Further reading 85
- 4 Protected areas, off-reserve conservation and managed populations 87**
- 4.0 Introduction 87
 - Protected areas 87
 - 4.1 Categories of protected areas 90
 - Other types of protected areas 90
 - 4.2 Protecting communities and ecosystems 93
 - Classifying and protecting ecosystem types: the Interim Biogeographic Regionalisation for Australia 93
 - Protecting IBRA regions 94
 - Classifying and protecting ecological communities 94
 - Ecosystem types, vegetation communities and the adequacy of protection 97
 - 4.3 Off-reserve conservation 98
 - Limitations of a reserve-only focus for biodiversity conservation 99
 - Impediments to expanding reserve systems 101
 - Intensification of exploitation and downgrading the conservation value of unreserved land 103
 - Impacts of external factors on conditions within reserves 104
 - Barriers to off-reserve conservation 105
 - Summary: off-reserve conservation 105
 - 4.4 Botanic gardens and zoos 106
 - Botanic gardens 106
 - Zoos 106
 - 4.5 Gene banks and storage facilities 109
 - Field gene banks 109
 - Seed banks 109
 - In vitro* storage 110
 - Ex situ* conservation of microbial diversity 111

4.6	Reintroduction, translocation and captive breeding	111	5.3	Climate change	138
	Types of relocations	111		The human basis for climate change	138
	Prevalence of translocation and reintroduction	113		Predicting future climate change	139
	Translocations, reintroductions and former ranges of species	113		Impact of climate change on species distribution patterns	140
	Effectiveness of reintroduction and translocation strategies	114		Climate change and reserve design	143
	Why reintroductions and translocations fail	114		Other impacts of climate change on biodiversity	143
	Cost and cost-effectiveness of reintroduction strategies	115	5.4	Conclusions	144
4.7	Conclusions	117	5.5	Practical considerations	145
4.8	Practical considerations	119	5.6	Further reading	145
4.9	Further reading	119	6	Loss of genetic diversity, populations and species	147
Part II: Impacts		121	6.0	Introduction	147
5	Changes in the physical environment	123	6.1	Loss of genetic variation	147
5.0	Introduction	123		Inbreeding	147
5.1	Land degradation, water resources and salinisation	123		Outbreeding	150
	Land degradation	123		Bottlenecks	151
	Water in the Australian environment	124		Hybridisation and swamping	152
	Aridity, variability and the Australian biota	124		Mutational meltdown	153
	Salinisation	129		Summary: loss of genetic variation	153
5.2	Chemical pollution	135	6.2	Background extinction rates	154
	Agricultural and other chemicals	136	6.3	Mass extinction events	155
	Excessive inputs of nutrients into ecosystems	136	6.4	Extinction rates in recent history	156
	CFC-induced ozone depletion	137		Extinctions in Australia	158
	Other chemical pollutants	137	6.5	Future extinction rates	163
	Limiting chemical pollution	138	6.6	Conclusions	164
			6.7	Practical considerations	165
			6.8	Further reading	165
			7	Changes in species distributions and abundances	167
			7.0	Introduction	167
			7.1	Range contraction and depletion	167
				Mammals	167

- Amphibians 168
- Range contraction and natural distribution and abundance patterns 170
- Migratory species: a special case of range conservation 171
- 7.2 Range expansion 173
- 7.3 Exotic animals 175
 - Exotic vertebrates 175
 - Exotic invertebrates 183
 - Exotic marine organisms and ballast water 186
- 7.4 Exotic plants 187
 - Types of weeds 187
 - Weeds in Australian plant communities 187
 - Rates of naturalisation 190
 - Mechanisms of introduction 190
 - Weeds and pasture productivity for grazing 190
 - Weed dispersal and the impacts of motor vehicles 192
 - Environmental impacts of weeds 192
 - Weeds and animal populations 192
 - Weed control 193
 - Prevention 193
- 7.5 Australian exports 196
- 7.6 Genetically engineered species 196
 - Transgenic varieties and genetically modified organisms 197
 - Potential benefits of genetically modified organisms 198
 - Risks of genetically modified organisms 199
 - Assessing the effects of genetically modified organisms 200
- 7.7 Pathogens 201
 - Cinnamom Fungus 201
 - Other diseases 202
- 7.8 Conclusions 202
- 7.9 Practical considerations 202
- 7.10 Further reading 203
- 8 Harvesting natural populations 205**
 - 8.0 Introduction 205
 - 8.1 Native forest harvesting 207
 - Definition of forest cover 207
 - Early vegetation clearing and the establishment of State forests 208
 - Native forest harvesting 208
 - Regional Forest Agreement process 211
 - Criteria and indicators of sustainability 212
 - Forest industry certification 212
 - Summary: native forest harvesting 214
 - 8.2 Plantation forestry 214
 - Australian plantations 214
 - Why biodiversity conservation within plantations is important 215
 - Plantation establishment and biodiversity 215
 - 8.3 Kangaroo harvesting 217
 - History of Kangaroo harvesting in Australia 217
 - Data input to guide Kangaroo harvesting 218
 - Setting quotas for Kangaroo harvesting 218
 - Ethical positions and perspectives on Kangaroo harvesting 219

- 8.4 Fisheries 219
 - The complexity of fisheries management 219
 - Stages of fisheries collapse 220
 - By-catch impacts 221
 - Cascading impacts of overfishing 222
 - Australian fishing industry 223
 - Status of Australian fishery stocks 223
 - Example of a sustainable fishery 224
 - Future issues and approaches to sustainability 224
- 8.5 Conclusions 227
- 8.6 Practical considerations 227
- 8.7 Further reading 227
- 9 Vegetation loss and degradation 229**
 - 9.0 Introduction 229
 - 9.1 Vegetation clearing and habitat loss in Australia 230
 - Australia's contribution to global levels of land clearing and vegetation loss 230
 - Past land-clearing patterns in Australia 231
 - Clearing by land-use zone 232
 - Clearing rates and land tenure 233
 - Vegetation types that have been cleared 234
 - Land clearing impacts on biodiversity 236
 - Dieback 238
 - 9.2 Mining and urbanisation 240
 - Mining 240
 - Impacts of urbanisation 244
 - 9.3 Traditional Aboriginal use and pastoralism 248
 - Traditional Aboriginal land use 248
 - Pastoralism 250
 - 9.4 Conclusions 253
 - 9.5 Practical considerations 254
 - 9.6 Further reading 254
- 10 Landscapes and habitat fragmentation 255**
 - 10.0 Introduction 255
 - 10.1 Ways that landscapes can be altered 256
 - Vegetation cover patterns that arise from habitat loss and habitat fragmentation 257
 - Dynamism in the patterns of vegetation cover 258
 - 10.2 Models of landscape cover 260
 - Island model 260
 - Nested subset theory 261
 - Patch-matrix-corridor model 262
 - Habitat-variegation or landscape continuum model 262
 - Congruence between the patch-matrix-corridor and continuum landscape models 264
 - Limitations in the application of the landscape models 264
 - Landscape contour approach 265
 - 10.2 Ecological processes and species responses to habitat loss and fragmentation 266
 - Context for habitat loss and habitat fragmentation 266
 - Problems with the term 'habitat fragmentation' 266
 - Five processes associated with landscape change 267
 - Habitat loss 268
 - Vegetation loss, threshold effects and species loss 269

- Cascading fragmentation effects 270
- Vegetation subdivision, patch isolation and dispersal 271
- Edge effects 273
- 10.4 Studying habitat loss and fragmentation 275
 - Experiments 277
 - 'Natural' experiments 279
 - Observational studies 279
 - Modelling 280
 - Problems in the way fragmentation is studied 281
- 10.5 Forecasting fragmentation effects 283
 - Predictive ability, generality and meta-analyses 283
- 10.6 Limiting the effects of habitat loss and fragmentation 284
 - Limiting and reversing habitat loss 284
 - Maintaining habitat quality 285
 - Increasing connectivity 285
 - Wildlife corridors as a way to maintain connectivity 286
 - Other approaches to enhancing connectivity 289
 - Reducing edge effects: buffer systems 289
 - General principles for landscape management to mitigate habitat loss and fragmentation 290
- 10.7 Conclusions 291
- 10.8 Practical considerations 291
- 10.9 Further reading 292
- 11 Fire and biodiversity 293**
 - 11.0 Introduction 293
 - 11.1 Brief history of fire in Australia 293
 - 11.2 Types of fire 296
 - Wildfire 297
 - Prescribed fires 297
 - 11.3 Response of biodiversity to wildfire 298
 - Wildfire and Australian animals 298
 - Wildfire and Australian plants 301
 - Wildfire and identifying patterns of species responses 302
 - 11.4 Response of biodiversity to prescribed fire 303
 - 11.5 Species vulnerability to fire 304
 - Animal and plant groups threatened by altered fire regimes 304
 - Vegetation communities sensitive to fire 304
 - 11.6 Spatial variability in fire behaviour: fire refugia, landscape mosaics, and Aboriginal burning patterns 306
 - Fine-scale vegetation mosaics and Aboriginal burning 306
 - 11.7 Fire management and biodiversity conservation 307
 - Fire management and conservation of the Eastern Bristlebird and the Ground Parrot 307
 - 11.8 Studies to examine the effects of fire 309
 - Experiments 309
 - Observational studies 310
 - Modelling 310
 - 11.9 Ecological theories, fire disturbance and biodiversity conservation 311
 - The biological legacies concept and biodiversity 311

Congruence between human disturbance and natural disturbance: values and limitations	312	Coastal zone and the human population	327
Fire and logging	313	Policy problems and solutions in coastal management	330
Intermediate disturbance hypothesis	314	12.4 Murray–Darling Basin	331
11.10 Cumulative effects of fire and other disturbance processes	314	Degradation in the Murray–Darling Basin	331
11.11 Fire and reserve design	315	Biodiversity in the Murray–Darling Basin	332
11.12 The future	316	Solutions to problems in the Murray–Darling Basin	332
11.13 Conclusions	316	12.5 Conclusions	332
11.14 Practical considerations	317	12.6 Practical considerations	333
11.15 Further reading	317	12.7 Further reading	333
12 Demands of the human population	319	Part III: Methods of analysis	335
12.0 Introduction	319	13 Measuring, managing and using genetic variation	337
12.1 The world population	320	13.0 Introduction	337
Per capita consumption	320	13.1 Types of data	337
Impacts of the human population on the environment	322	DNA and electrophoresis	337
Human populations and biodiversity loss	322	Restriction fragment length polymorphism	338
12.2 Demands of the Australian population	322	DNA sequencing	338
Future size of Australia’s population	322	Single nucleotide polymorphism	339
Energy demands and greenhouse gas production of Australia’s human population	323	Randomly amplified polymorphic DNA	339
Future Australian populations and future resource use	324	Minisatellite and microsatellite analysis	339
Australia’s carrying capacity	325	Ribosomal DNA analysis	339
Australian population and biodiversity loss	325	Mitochondrial DNA analysis	339
12.3 Coastal zone	326	Chloroplast DNA (cpDNA) analysis	340
Uniqueness of the Australian coastal zone	326	Allozyme analysis	341
		Quantitative characters	341

13.2 Molecular ecology	342	15.2 Qualitative habitat models	368
Understanding social structure	342	Potential limitations of the HSI approach	369
Estimating effective population size	343	Advantages of the HSI approach	371
Detecting migration	346	15.3 Statistical habitat models	371
Effects of genetic change on demographic parameters	348	Logistic regression	371
13.3 Gene conservation	348	Reliability measures for statistical models	375
Spatial structure	349	Making a spatial prediction of potentially suitable habitat	375
Setting priorities for conservation	349	Poisson regression	376
Managing captive populations	352	Summary: statistical habitat modelling	379
13.4 Conclusions	354	15.4 Envelopes and bioclimatic modelling	379
13.5 Practical considerations	354	BIOCLIM and bioclimatic modelling	380
13.6 Further reading	355	Applications of bioclimatic analyses	381
14 Measuring diversity	357	15.5 Conclusions	383
14.0 Introduction	357	15.6 Practical considerations	384
14.1 Estimating species richness	357	15.7 Further reading	384
Species accumulation indices	358	16 Reserve design	385
Ratio estimation	359	16.0 Introduction	385
14.2 Detecting rare species	360	16.1 <i>Ad hoc</i> developments	385
14.3 Species diversity	361	16.2 CAR reserve system design principles	386
Alpha diversity	361	16.3 Reserve design and biodiversity surrogate schemes	386
Beta and gamma diversity	363	Types of surrogates	386
A test for change in community structure	363	Environmental domains	387
14.4 Landscape diversity	364	Vegetation maps	387
14.5 Conclusions	365	Centres of diversity	387
14.6 Practical considerations	366	Potential limitations of surrogates	388
14.7 Further reading	366	The need to test surrogates	388
15 Identifying habitat	367	16.4 Reserve selection	389
15.0 Introduction	367	Potential limitations of reserve selection methods	391
Defining habitat	367	Reserve adequacy	391
15.1 Methods for identifying habitat requirements	368		

- 16.5 Reserve design and selection in the real world 392
 - Differences in the land base and competing demands for land 394
- 16.6 Island biogeography and the design of nature reserves 395
 - Problems with the 'generic reserve design principles' derived from the island biogeography theory 396
 - Why island biogeography theory has limited applicability to reserve design 398
 - Summary: island biogeography theory and reserve design 399
- 16.7 Conclusions 399
- 16.8 Practical considerations 400
- 16.9 Further reading 400
- 17 Monitoring, assessment and indicators 401**
 - 17.0 Introduction 401
 - 17.1 Statistical power and the precautionary principle 402
 - Statistical power 404
 - Power and the precautionary principle 404
 - 17.2 Management goals, assessment endpoints and measurement endpoints 406
 - 17.3 Indicators 410
 - Species as indicators 410
 - Keystone species and indicator species 412
 - Ecological redundancy 414
 - Guilds as indicators 414
 - Problems with indicator species and related concepts 415
 - Summary: indicator species 418
 - 17.4 Selecting indicators 419
 - Examples of the selection of suites of indicators 421
 - 17.5 Conclusions 423
 - 17.6 Practical considerations 423
 - 17.7 Further reading 423
- 18 Risk assessment 425**
 - 18.0 Introduction 425
 - 18.1 Estimating extinction rates 425
 - 18.2 Estimating the likelihood of extinction from collections 426
 - 18.3 Population management and risk 428
 - Types of uncertainty 431
 - 18.4 Expert judgement 432
 - 18.5 Population viability analysis 436
 - Models for PVA 436
 - A model for Matchstick Banksia 438
 - Metapopulations 441
 - Metapopulations in a PVA framework 442
 - Caveats for metapopulation modelling 443
 - Minimum viable populations 443
 - The limits of population viability analysis 444
 - 18.6 Conclusions 446
 - 18.7 Practical implications 447
 - 18.8 Further reading 447
- Part IV: Management principles for conservation 449**
- 19 Sustainability and management 451**
 - 19.0 Introduction 451
 - 19.1 Sustainability 451
 - Maximum sustainable yield 453
 - Forests 453

Fisheries	454	Adaptive management in the real world	462
Maximum sustainable yield and uncertainty	454	19.3 Ecosystem management	463
Sustainable development	455	19.4 Policy and science in conservation biology	464
International conventions on sustainability	457	19.5 Conclusions	465
Globalisation, sustainability and biodiversity conservation	458	19.6 Practical considerations	468
19.2 Adaptive management	459	19.7 Further reading	468
A formalised approach to adaptive management	460	Appendix I: Taxonomic names	469
Adaptive management in a political context	461	Appendix II: Glossary	477
		Bibliography	497
		Index	601