

Contents

Acknowledgements	ix
About the companion website	xi
1 Where Are We and How Did We Arrive Here?	1
1.1 Why this book?	1
1.2 Ecosystems in crisis	2
1.3 Relevance of the past	5
1.4 Forecasting the future	7
1.5 Chapter details and logic	9
1.6 For whom is the book intended?	12
1.7 Four key questions and the links to policy	13
2 Modelling	15
2.1 Introduction	15
2.1.1 How did these models develop?	16
2.1.2 Climate data, climate and earth system models	16
2.2 Background ecosystem, vegetation and species models	18
2.2.1 Vegetation models	18
2.2.2 Species-level modelling	25
2.2.3 Equilibrium physiologically-based modelling of species	27
2.2.4 Statistical equilibrium modelling of species	30
2.2.5 Some uncertainties and assumptions that apply generally to bioclimatic models	31
2.2.6 Models of intermediate complexity	32
2.2.7 Biogeochemistry integrated into equilibrium biome models	33
2.2.8 Integrating biome and NPP models	35
2.3 Dynamic modelling	36
2.3.1 Local to landscape scales: forest gap modelling	36
2.3.2 Regional to global scales: dynamic global vegetation modelling	38
2.4 Integrating models	44
2.4.1 Earth system models	44
2.4.2 Integrated assessment models	45
2.4.3 Agent-based models	48
2.5 Further reading	48

3	Data	49
3.1	Introduction	49
3.2	Which data are relevant?	50
3.3	Ecosystem dynamics: direct observation	51
3.3.1	Phenology	51
3.3.2	Biological monitoring	53
3.4	Ecosystem dynamics: indirect measurement or proxy data	56
3.4.1	Historical ecology	57
3.4.2	Palaeoecology	58
3.4.3	Pollen analysis	60
3.4.4	Charcoal and fire scars	63
3.5	Drivers of ecosystem dynamics	67
3.5.1	Palaeoclimates and greenhouse gases	67
3.5.2	Human impact on ecosystem dynamics	69
3.6	Databases	70
3.7	Gaps in available data and approaches	70
4	Climate Change and Millennial Ecosystem Dynamics: A Complex Relationship	73
4.1	Introduction	73
4.2	Reconstructing climate from biological data	74
4.3	The very long records of vegetation dynamics	78
4.4	Holocene records	81
4.5	Modelling of Holocene vegetation dynamics to help understand pollen data	83
4.5.1	Climate or people? The <i>Tilia</i> – <i>Fagus</i> transition in Draved Forest, Denmark	86
4.5.2	Climate or migration biology? The late-Holocene spread of <i>Picea</i> into southern Fennoscandia	87
4.5.3	<i>Fagus</i> in Europe	91
4.6	Simulating Fennoscandian Holocene forest dynamics	94
4.6.1	Holocene dynamics of the Sahara	98
4.7	Climate and megafaunal extinction	101
4.7.1	Recent range shifts	103
4.8	So how important is climate change for future millennial ecosystem dynamics?	103
5	The Role of Episodic Events in Millennial Ecosystem Dynamics: Where the Wild Strawberries Grow	109
5.1	Introduction	109
5.2	Fire	115
5.2.1	Past to present fire	116
5.2.2	Present to future fire	121
5.2.3	Modelling fire	121
5.2.4	Modelling ignition	122
5.2.5	Modelling fire spread	124
5.2.6	Data–model comparison	128
5.3	Forest pathogens during the Holocene	131
5.4	Hurricanes and wind damage	135
5.5	Conclusion	139
6	The Impact of Past and Future Human Exploitation on Terrestrial Ecosystem Dynamics	141
6.1	Introduction	141

6.2	Denmark: case study of human impact during the Holocene	146
6.3	Islands: sensitive indicators of human impact	152
6.4	Human influence on Mediterranean, temperate and boreal forests	157
6.5	The tropics	163
6.6	Spatial upscaling of the timing and ecosystem consequences of human impact	164
7	Millennial Ecosystem Dynamics and Their Relationship to Ecosystem Services: Past and Future	173
7.1	Introduction	173
7.2	MEA classification	176
7.2.1	Provisioning services	176
7.2.2	Regulating services	177
7.2.3	Cultural services	177
7.2.4	Supporting services	177
7.3	The current crisis in ecosystem services	179
7.3.1	How did we get here? A palaeo perspective	181
7.3.2	Provisioning services in the past	182
7.3.3	Regulating services in the past	185
7.3.4	Cultural services in the past	189
7.3.5	Supporting services in the past	190
7.4	Ecosystem services and the future	193
7.5	Relating the maintenance of biodiversity to ecosystem service provision	197
7.6	Scenarios of possible futures: some different approaches	197
7.6.1	IPCC Special report on emission scenarios	199
7.6.2	MEA scenarios	201
7.6.3	ALARM scenarios	203
7.7	So what do scenarios say about the possible futures for ecosystem services?	204
7.7.1	MEA scenarios	204
7.7.2	SRES scenarios	205
7.7.3	ALARM scenarios	207
8	Cultural Ecosystem Services	211
8.1	Introduction	211
8.2	Sacred sites and species	212
8.2.1	Some examples from around the globe	214
8.3	Cultural landscapes: biodiverse relicts of former land use systems	219
8.4	Hunting as a cultural ecosystem service	221
9	Conservation	225
9.1	Conservation as we know it	225
9.2	Knowledge of the past: relevance for conservation	228
9.2.1	Fire history, conservation and ecosystem restoration	229
9.2.2	Ecosystem restoration	234
9.2.3	The wood pasture debate	235
9.2.4	Reference states or baselines?	237
9.3	Conservation in practice: protected areas (Natura 2000)	242
9.4	Conservation and alien or invasive species	244
9.4.1	Alien species, climate change and conservation	248
9.5	Global change, biodiversity and conservation in the future	253
9.5.1	The Convention on biological diversity	254
9.5.2	Atlas of biodiversity risk	255
9.6	Conclusion	257

10	Where Are We Headed?	259
10.1	Introduction	259
10.2	Emergent themes and important underlying concepts	262
10.2.1	How have ecosystems changed in the past?	262
10.2.2	How much of this change is attributable to human activities?	263
10.2.3	How much change is anticipated for the future?	264
10.2.4	What are the appropriate ecosystem management measures by which to prepare for the future?	265
	References	271
	Glossary	297
	Index	311