Contents

Part I Introduction

1	The Need for a Holistic Approach in Mangrove Research and Management U. Saint-Paul and H. Schneider	3
2	MADAM, Concept and Reality U. Saint-Paul	ç
Par	t II Geography and Biogeochemistry	
3	The Geography of the Bragança Coastal Region	19
	G. Krause	
	3.1 Background and Scope	19
	3.2 Spatial Boundaries	
	3.3 Principal Features of the Natural and Social System	
	3.3.1 The Marine Seascape and the Estuary	
	3.3.2 The Coastline	
	3.3.3 The Intertidal Zone	
	3.3.4 The Rural Hinterland	
	3.3.5 The City of Bragança	
	3.4 Co-Evolutionary Outcomes of the Natural and Social	
	Dynamics	29
	References	
4	Palaeoenvironmental Reconstruction	35
	H. Behling, M. Cohen, R.J. Lara, and V. Vedel	
	4.1 Coastal Region of Northern Brazil	35
	4.2 Holocene Environmental Changes	2.



viii Contents

	4.3	Model of Bragança Mangrove Development	40
	4.4	Holocene Coastal Dynamics	42
	Ref	erences	43
5	The	e Biogeochemistry of the Caeté Mangrove-Shelf System	45
		. Koch, T. Dittmar, and R.J. Lara	
		Introduction and Overview	45
		Sediment Processes	46
		5.2.1 Fate and Decomposition of Leaf Litter in Mangrove	
		Sediments	46
		5.2.2 Long-Term Decomposition of Organic Matter	
		in Mangrove Sediments	47
		5.2.3 The Use of Chemical Biomarkers as Source Tracers	
		in Mangrove Sediments	49
	5.3	The Outwelling of Detritus and Decomposition Products	
		into Coastal Waters	52
		5.3.1 Quantifying the Export of Organic Matter	
		from the Mangrove into the Estuary	52
		5.3.2 Driving Forces Behind Nutrient and Organic Matter	
		Dynamics in Mangrove Creeks	54
		5.3.3 Water Storage in the Mangrove Sediment and Effect	
		on Creek Water Chemistry	54
		5.3.4 Effect of Autotrophic Activity in the Creek	57
		5.3.5 Requirements for Sustainable Outwelling	58
	5.4	The Fate of Mangrove Outwelling on the Continental Shelf	
	ъ.	and Concluding Remarks	60
	Ref	erences	64
Par	t III	Floristic and Faunistic Studies in Mangroves	
		Ç	
6		ngrove Vegetation of the Caeté Estuary	71
		Mehlig, M.P.M. Menezes, A. Reise, D. Schories, and E. Medina	
		Floristics and Forest Structure	71
	6.2	Litter Fall and Phenology	77
		6.2.1 Litter Fall Rates	79
		6.2.2 Phenology	81
	6.3	Dendrochronological Studies of <i>R. mangle</i> Trees	85
		6.3.1 Periodicity of Growth Rings, Life Span and Growth	0.0
		Curves of R. mangle	86
		6.3.2 Diameter Increment	87
		6.3.3 Mean Stand Age and Age Structure	88
	6.4	Soil-Vegetation Nutrient Relations	91
		6.4.1 Mangrove Communities and Methods	91
		6.4.2 Soil Physical–Chemical Properties and Flooding	93
		6.4.3 Forest Structure and Function	96

Contents ix

	6.4.4 Conclusions	102
	6.5 Concluding Remarks and Outlook	103
	References	104
7	Mangrove Infauna and Sessile Epifauna	109
	C.R. Beasley, M.E.B. Fernandes, E.A.G. Figueira, D.S. Sampaio,	
	K.R. Melo, and R.S. Barros	
	7.1 Introduction	109
	7.2 The Infauna of the Mangrove Forest at the Furo Grande	
	Tidal Creek	110
	7.3 Comparison of the Benthic Fauna Among Sites with Differing	
	Degrees of Degradation	113
	7.4 Settlement of the Tidal Creek Epifauna in the Caeté Mangrove	
	Estuary	115
	7.4.1 Fistulobalanus citerosum	116
	7.4.2 Crassostrea gasar	116
	7.4.2 Crassostrea gasar	118
		110
	7.5 Differences in Settlement of Epibenthos Between Mangrove	120
	and Tidal Creek Habitats	
	7.6 Conclusions	120
	References	120
n.	A IX. Dymania in the Manager Contains	
rar	t IV Dynamics in the Mangrove System	
Par	t IV Dynamics in the Mangrove System	
Par 8	Drivers of Temporal Changes in Mangrove Vegetation	
		127
	Drivers of Temporal Changes in Mangrove Vegetation	127
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use	127 127
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction	
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity	
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure	127
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone	127 127
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use	127 127 133
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes	127 127 133 133
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts	127 127 133 133 135
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use	127 127 133 133 135 137
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts	127 127 133 133 135
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References	127 127 133 133 135 137 140
	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development	127 127 133 133 135 137 140
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff	127 127 133 133 135 137 140
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff 9.1 The Interlink Between the Modeling Approaches	127 127 133 133 135 137 140 143
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff 9.1 The Interlink Between the Modeling Approaches 9.2 Trophic Pathways	127 127 133 133 135 137 140
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff 9.1 The Interlink Between the Modeling Approaches 9.2 Trophic Pathways 9.3 Forest Dynamics Under Different Natural Disturbance	127 127 133 133 135 137 140 143 144
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff 9.1 The Interlink Between the Modeling Approaches 9.2 Trophic Pathways 9.3 Forest Dynamics Under Different Natural Disturbance Regimes	127 127 133 133 135 137 140 143 144 146
8	Drivers of Temporal Changes in Mangrove Vegetation Boundaries and Consequences for Land Use R.J. Lara, M. Cohen, and C. Szlafsztein 8.1 Introduction 8.2 Influence of Inundation Frequency and Sediment Salinity on Wetland Structure 8.3 Changes in Current Vegetation Units: Boundaries, Ecotone Shifts and Consequences for Land Use 8.3.1 Coastline Vegetation Changes 8.3.2 Ecotone Shifts 8.3.3 Consequences for Land Use References System Processes and Forest Development U. Berger and M. Wolff 9.1 The Interlink Between the Modeling Approaches 9.2 Trophic Pathways 9.3 Forest Dynamics Under Different Natural Disturbance	127 127 133 133 135 137 140 143 144

x Contents

10	Synoptic Analysis of Mangroves for Coastal	
	Zone Management	153
	G. Krause and M. Bock	
	10.1 Background and Scope	153
	10.2 Research Strategy	154
	10.3 Change Dynamics	156
	10.3.1 Regional Scale Analysis	156
	10.3.2 Local Scale Analysis	157
	10.4 Classification of Mangrove Patterns	159
	10.4.1 Aerial Survey Analysis	159
	10.4.2 Classification of Mangrove Patterns on the Peninsula with IKONOS Data	161
	10.5 Potential Contributions to Coastal Zone Management	163
	References	165
Par	et V Ecology and Fishery of Fin-Fish in the Mangrove System	
11	Distribution Pattern of Fish in a Mangrove Estuary	171
	M. Barletta and U. Saint-Paul	
	11.1 Seasonal Changes in Fish Density and Biomass in the Caeté	
	Estuary	171
	11.1.1 The Main Channel	172
	11.1.2 The Mangrove Tidal Creeks	178
	11.2 Fish Assemblage Patterns	180
	11.2.1 Seasonal Movements	180
	11.2.2 Fish Shelter Strategies in Mangrove Forests	
	and Tidal Channels	185
	References	186
12	Dynamics in Mangrove Fish Assemblages	100
	on a Macrotidal Coast U. Krumme and U. Saint-Paul	189
		100
	12.1 Introduction	189
	12.2 Environmental Setting	189
	12.3 Nekton Sampling in Macrotidal Environments	190
	12.4 Trends in Species Richness, Biomass and Density along	100
	a Shoreline Gradient	192
	12.5 Composition of Transients	194
	12.6 Tidal Movements	194
	12.7 Tidal and Diel Changes in the Intertidal Fish Assemblages	197
	12.8 Tide-to-Tide, Weekly, Fortnightly and Monthly Variation	
	in Abundance, Catch Weight, and Species Richness	
	of Transients	199
	12.9 Patterns in Feeding	202

Contents xi

	12.10 Spatial Patterns in the Intertidal Fish Fauna	203
	Monitoring	204
	References	205
13	An Evaluation of the Larval Fish Assemblage in a North	
	Brazilian Mangrove Area	209
	A. Barletta-Bergan	
	13.1 Value of Mangroves and Estuaries as Nurseries	209
	13.2 First Ichthyoplankton Survey	209
	13.3 A North Brazilian Larval Fish Community in Relation	
	to Mangroves Worldwide	210
	References	217
14	Molecular Phylogenetic and Population Genetic Structuring	
	of Macrodon sp., a Coastal and Estuarine Fish of the Western	
	Atlantic Ocean	221
	I. Sampaio, S. Santos, and H. Schneider	
	14.1 Phylogenetic Studies in Fish Populations	221
	14.2 Genetic Differentiation of Macrodon	223
	14.3 Consequences for the Taxonomy of Macrodon	228
	References	230
15	Fisheries and Management	233
	V.J. Isaac, R.V.E. Santo, and U. Saint-Paul	
	15.1 Introduction	233
	15.2 Methods	234
	15.3 Fisheries Structure and Situation	235
	15.4 Recommendations	246
	References	247
Par	t VI Ecology and Fishery of Mangrove Crabs	
17	The David Control of C	
16	The Brachyuran Crab Community of the Caeté Estuary, North Brazil: Species Richness, Zonation and Abundance	251
		231
	K. Diele, V. Koch, F.A. Abrunhosa, J. de Farias Lima, and D. de Jesus de Brito Simith	
		251
	16.1 Background and Scope	251
	16.2 Species Richness and Zonation	
	16.3 Abundance and Biomass	259
	16.4 Biogeographic Comparison	260
	References	261

xii Contents

17	Feeding Ecology and Ecological Role of North Brazilian	
	Mangrove Crabs	265
	V. Koch and I. Nordhaus	
	17.1 Feeding Guilds	265
	17.2 Feeding Periodicity	266
	17.3 Food Intake	268
	17.4 Ecological Role	270
	References	271
18	Comparative Population Dynamics and Life Histories	
	of North Brazilian Mangrove Crabs, Genera Uca and Ucides	
	(Ocypodoidea)	275
	K. Diele and V. Koch	
	18.1 Individual Size, Population Size Structure and Sex Ratio	275
	18.2 Growth and Mortality	277
	18.3 Reproduction	279
	18.4 Contrasting Life Histories: Large, Long-Lived and Litter	
	Feeding Versus Small, Short-Lived and Deposit Feeding	281
	References	283
19	Artisanal Fishery of the Mangrove Crab Ucides cordatus	
	(Ucididae) and First Steps Toward a Successful Co-Management	
	in Bragança, North Brazil	287
	K. Diele, A.R.R. Araújo, M. Glaser, and U. Salzmann	
	19.1 Background and Scope	287
	19.2 Capture Areas, Capture Techniques and Effort	288
	19.3 Standing Stock and Fishery Yields	291
	19.4 Legislation	293
	19.5 Marketing Systems	294
	19.6 Significance of Community Participation in Research	- ,
	and Management	295
	References	296
	Note to the control of the control o	2,0
20	Simulating Ucides cordatus Population Recovery	200
	on Fished Grounds	299
	C. Piou, U. Berger, and K. Diele	200
	20.1 The Individual-Based-Ucides Model	299
	20.2 Inferences with the Pattern-Oriented Modeling Approach	300
	20.3 Importance of Movements Induced by Density-Dependent	*
	Processes	302
	References	303

Contents xiii

Part	VII	Mangrov	ves and	People
ıaıı	A 17	TYLAHELU'	ves anu	1 CODI

21	Man	groves and People: A Social-Ecological System	307
	M. C	Glaser, G. Krause, R.S. Oliveira, and M. Fontalvo-Herazo	
	21.1	The Social-Ecological System (SES) Concept	307
	21.2	Mangrove Values and Livelihoods	309
		21.2.1 Mangrove Dependence	310
		21.2.2 Economic Value and Poverty	312
	21.3	The Coevolution of Natural and Social System Drivers	
		at the Local Level	314
		21.3.1 Ajuruteua: A Coastal Village	315
		21.3.2 Tamatateua: An Agricultural Village	318
		21.3.3 Social-Ecological Systems as Co-evolving Entities	322
	21.4	Sustainability Visions and Indicators	323
		21.4.1 Introduction	323
		21.4.2 Case Study: An Indicator System as an Integrative and	
		Transdisciplinary Tool	325
		21.4.3 The Social Dimension	327
	21.5	Participatory Management of Coastal Ecosystems	330
		21.5.1 Outlook	333
	21.6	Scenarios for Mangrove-Based Social-Ecological Systems:	
		Linking Futures Across Stakeholder Rationalities	334
		21.6.1 Setting Up Social-Ecological Scenarios	334
		21.6.2 Possible Futures of the Mangrove-Based SES	335
		21.6.3 Inclusion of "the Social Dimension" as Central Element	
		Towards Sustainability in SES	338
	21.7	Appropriate Knowledge for a Mangrove-Based	
		Social-Ecological System: Outlook for Future Work	340
		21.7.1 Identify Undesirable Feedback Loops and Modes	
		of Addressing Them	341
		21.7.2 Assign Adequate Values to Poverty Alleviation	
		Functions	342
		21.7.3 Develop Alternatives to Unsustainable Forms	
		of Behavior Towards Nature	343
		21.7.4 Recognize, Evaluate and Link Knowledge Systems	343
		21.7.5 Build an Effective Social Base	344
		21.7.6 Collectively Envision Desirable Futures	345
		21.7.7 Achieve Relevance and Sustainability at Multiple	
		Scales from the Local to the Global	346
	Pofo	rances	347

xiv Contents

	Part	VIII	Data	Synthesis an	d Assessment	Tools
--	------	------	------	--------------	--------------	-------

22	The	Mangrove Information System MAIS: Managing	
		Integrating Interdisciplinary Research Data	355
		alzmann, G. Krause, B.P. Koch, and I. Puch Rojo	
		Introduction	355
		Implementation of a GIS-Database	356
		Database Model and Data Management	357
		MAIS: A Tool for Supporting Interdisciplinary Research?	360
	¬	22.4.1 Quality Control and Improved Analysis Tools	361
		22.4.2 Appropriate Support and Funding	361
			301
		22.4.3 Intellectual Property Rights and Better Incentives	362
	22.5	for Data Sharing	
		Concluding Remarks	362
	Refe	rences	363
23	Coas	stal Zone Management Tool: A GIS-Based Vulnerability	
		essment to Natural Hazards	365
		zlafsztein and H. Sterr	
	23.1	Coastal Zone-Dynamic and Vulnerable Environment	365
	2011	23.1.1 The Northeast Part of Coastal Zone of the State of Pará:	
		The Study Area	367
		23.1.2 The Natural Hazards Impacts	369
		23.1.3 GIS-Based Composite Vulnerability Index	
		for the Coastal Zone	370
	23.2	General Concepts	371
		23.2.1 Data Problems and Shortcomings in Northeast Pará	371
		23.2.2 Design of Composite Vulnerability Index,	
		Based on GIS	372
	23.3	Socio-economic and Natural Vulnerability	374
		Conclusions	380
		rences	383
Par	t IX	Closing Remarks	
24	Enile	og	389
	•	aint-Paul and H. Schneider	
		rences	392
			20.
Ind	ex		395