

# Table of Contents

<i>Foreword</i>	<i>page</i> xiii
<i>Preface</i>	xv
<i>Acknowledgments</i>	xvii

---

<b>Part I</b>	<b>The Tropical Environment</b>	<b>I</b>
<b>1</b>	<b>The Natural Environment of the Tropics</b>	<b>3</b>
1.1	The Tropics Defined	3
1.2	Temperature and Solar Radiation	4
1.3	Rainfall	6
1.4	Tropical Climates	11
1.5	Vegetation	14
1.6	Physiography	22
1.7	The Anthropocene	24
1.8	Biodiversity in the Tropics	25
1.9	Climate Change	26
1.10	Summary and Conclusions	30
<b>2</b>	<b>The Human Environment of the Tropics</b>	<b>36</b>
2.1	Demographics	37
2.2	Key Concepts	39
2.3	The Fight Against Hunger and Absolute Poverty	42
2.4	The Food Versus Population Race	45
2.5	Green Revolutions	46
2.6	Tropical Agroecosystems	53
2.7	Land Use and Land-Use Change	54
2.8	Intensification and Extensification	58
2.9	Summary and Conclusions	63
<b>Part II</b>	<b>Pedology, Physics, Chemistry and Biology</b>	<b>67</b>
<b>3</b>	<b>History of Soil Science in the Tropics</b>	<b>69</b>
3.1	The Laterite Paradigm	70
3.2	Tropical Soils Are Very Diverse	71
3.3	Tropical Soil Research: 1970s to 1990s	72
3.4	The First Soil Management Paradigm	73
3.5	The Second Soil Management Paradigm	74
3.6	The Third Soil Management Paradigm	75
3.7	Soils in a Global Context	75
3.8	Summary and Conclusions	77
<b>4</b>	<b>Soils of the Tropics</b>	<b>82</b>
4.1	Soil Taxonomy	83
4.2	World Reference Base for Soil Resources	92
4.3	A National Soil Classification System: Cuba	92
4.4	Main Soils of the Tropics	97
4.5	Soils at the Landscape Scale	109
4.6	Importance of Soil Diversity to Ecologists and Modelers	115
4.7	Summary and Conclusions	115

<b>5 Functional Capability Classification</b> .....	120
5.1 System Structure and Definitions .....	120
5.2 Areal Extent of FCC Attributes .....	121
5.3 Attributes Related to Soil Mineralogy .....	123
5.4 Attributes Related to Soil Organic Matter .....	126
5.5 Attributes Related to Soil Physical Properties .....	127
5.6 Attributes Related to Soil Reaction (pH) .....	128
5.7 Regional Differences .....	129
5.8 Interpreting FCC Classes .....	130
5.9 Actual and Potential Use of FCC .....	130
5.10 Summary and Conclusions .....	131
<b>6 Soil Physical Properties</b> .....	134
6.1 Depth of Rooting .....	135
6.2 Soil Temperature .....	135
6.3 Soil Structure .....	136
6.4 Soil Compaction .....	143
6.5 Soil Water .....	146
6.6 Soil Erosion .....	151
6.7 Soil and Water Conservation Practices .....	156
6.8 Conservation Agriculture .....	162
6.9 Summary and Conclusions .....	169
<b>7 Water</b> .....	176
7.1 Overall Perspective .....	177
7.2 Metrics .....	178
7.3 Rainfed Agriculture .....	180
7.4 Irrigated Agriculture .....	186
7.5 Irrigation and Carbon .....	192
7.6 Perspectives .....	192
7.7 Summary and Conclusions .....	193
<b>8 Mineralogy</b> .....	196
8.1 Basic Concepts .....	196
8.2 Paradigm Shifts .....	197
8.3 Types of Clay Minerals .....	197
8.4 Mineralogy Families .....	199
8.5 Measurement Issues .....	200
8.6 pH–Charge Relationships .....	202
8.7 Anion Exchange Capacity: An Asset of the Tropics .....	206
8.8 Summary and Conclusions .....	207
<b>9 Soil Acidity</b> .....	210
9.1 Causes of Soil Acidity .....	211
9.2 Acid Soil Infertility .....	215
9.3 Genetic Differences in Aluminum Tolerance .....	218
9.4 Liming .....	221
9.5 Overliming .....	226
9.6 Residual Effects of Liming .....	226
9.7 Subsoil Acidity .....	227
9.8 Secondary Acidity .....	229
9.9 Advantages of Acid Soils .....	231
9.10 Summary and Conclusions .....	231
<b>10 Soil Biology</b> .....	236
10.1 Definitions .....	237
10.2 Soil Biodiversity .....	237

10.3	Ecosystem Functions and Services	238
10.4	Comminution	238
10.5	Decomposition	239
10.6	Transformation of Nutrient Elements	242
10.7	Soil Structure Regulation	242
10.8	The Root Extenders: Mycorrhizae	246
10.9	Soil Biodiversity and Land-Use Change	250
10.10	Reflections	253
10.11	Summary and Conclusions	254
<b>11</b>	<b>Organic Carbon</b>	<b>259</b>
11.1	History of SOC Research	260
11.2	Tropical Soils and the Global Carbon Cycle	260
11.3	SOC in Tropical and Temperate Regions	263
11.4	Carbon Pools and Fractions	266
11.5	Carbon Sequestration	269
11.6	Animal Manures	278
11.7	Composts	284
11.8	Biochars	284
11.9	Organic Farming	289
11.10	Summary and Conclusions	297
<b>Part III Soil Fertility</b>		<b>307</b>
<b>12</b>	<b>Soil Fertility Principles</b>	<b>309</b>
12.1	The Law of the Minimum	311
12.2	Synchrony	311
12.3	Nutrient Cycling	311
12.4	Nutrient Uptake by Crops and Cycling	312
12.5	Determining Fertilizer Needs	313
12.6	Early Twenty-First-Century Paradigm Shifts	319
12.7	Summary and Conclusions	322
<b>13</b>	<b>Nitrogen</b>	<b>326</b>
13.1	The Nitrogen Cycle	327
13.2	Nitrogen Pools and Fractions	329
13.3	Atmospheric Deposition	329
13.4	Biological Nitrogen Fixation	330
13.5	Mineral Fertilizers	338
13.6	Organic Nitrogen Mineralization	342
13.7	Nitrogen Fertilizer Reactions in Soils	344
13.8	Fluctuations of Inorganic Nitrogen	345
13.9	Combining Mineral and Organic Nitrogen Fertilizers	348
13.10	Environmental Consequences	351
13.11	Efficiency of Nitrogen Fertilization	358
13.12	Profitability	361
13.13	Summary and Conclusions	362
<b>14</b>	<b>Phosphorus</b>	<b>370</b>
14.1	The Phosphorus Cycle	371
14.2	Total Soil Phosphorus	374
14.3	Inorganic Phosphorus	374
14.4	Organic Phosphorus	378
14.5	Phosphorus Sorption and Release	380
14.6	Soil Tests for Available Phosphorus	387
14.7	Plant Phosphorus Requirements	387
14.8	Phosphorus Fertilization	390

14.9	Residual Effects and Efficiency of Utilization	401
14.10	Summary and Conclusions	406
<b>15</b>	<b>Sulfur</b>	<b>415</b>
15.1	The Sulfur Cycle	416
15.2	Sulfur Sorption	419
15.3	Crop Requirements	422
15.4	Nutrition	422
15.5	Soil Testing	422
15.6	Sulfur Fertilization	424
15.7	Summary and Conclusions	426
<b>Part IV Management Systems</b>		<b>431</b>
<b>16</b>	<b>Soils and Slash-and-Burn Agriculture</b>	<b>433</b>
16.1	Shifting Cultivation and Slash-and-Burn Agriculture	435
16.2	Forest–Soil Nutrient Cycles	437
16.3	Land Clearing by Slash and Burn	444
16.4	Mechanized Land Clearing	453
16.5	Crop Yield Declines and Field Abandonment	458
16.6	Secondary Forest Fallows	461
16.7	Alternatives to Slash and Burn	464
16.8	Combining Agricultural Intensification with Decreased Deforestation	479
16.9	Summary and Conclusions	482
<b>17</b>	<b>Soil Management in Rice Cultivation</b>	<b>492</b>
17.1	Physical Consequences of Flooding	493
17.2	Puddling	494
17.3	Chemical and Biological Consequences of Flooding	497
17.4	Rice Cultivation Systems	506
17.5	Water	511
17.6	Nutrient Management	515
17.7	Yield Stagnation: Nitrogen Sequestration	525
17.8	Environmental Dimensions	526
17.9	The Way Forward	532
17.10	Summary and Conclusions	534
<b>18</b>	<b>Soils and Livestock-Based Tropical Systems</b>	<b>544</b>
18.1	Tropical Livestock in the Global Context	544
18.2	Tropical Pastures	547
18.3	Nutrient Cycling	557
18.4	Tropical Livestock Management Systems	571
18.5	Pastoralism	571
18.6	Smallholder Mixed Crop–Livestock Systems	574
18.7	Extensive Pasture-Based Beef Production	578
18.8	Pasture Degradation	581
18.9	Crop–Pasture Integration	582
18.10	Livestock and the Environment	584
18.11	Summary and Conclusions	587
<b>19</b>	<b>Soils and Tropical Tree-Based Systems</b>	<b>596</b>
19.1	Plantation Forestry	597
19.2	Plantation Forestry Species	598
19.3	Growth Stages of Tree Plantations	599
19.4	Hydrology of Tropical Forestry Plantations	605
19.5	Agroforestry	609

---

19.6	More People, More Trees .....	610
19.7	Agroforestry Tree Species .....	611
19.8	Classification of Agroforestry Systems .....	612
19.9	Simultaneous Agroforestry .....	613
19.10	Sequential Agroforestry: A Different Story .....	622
19.11	Tree Crops .....	632
19.12	Environmental Consequences .....	641
19.13	Summary and Conclusions .....	643
	<i>Index</i> .....	653

