

Contents

Introduction	xiii
Yves COQUET and Joël MICHELIN	
Chapter 1. Tillage and Structure of Agricultural Soils	1
Yves COQUET and Lionel ALLETTO	
1.1. What is tillage? Why should soils be “tilled”?	1
1.2. Soil structure	3
1.2.1. Porosity and bulk density	4
1.2.2. Soil structuring mechanisms	6
1.2.3. A method for characterizing the structure of cultivated soils: the “ <i>Profil cultural</i> ”	13
1.3. Consequences of the different methods for tilling soil	15
1.3.1. Systems that include tillage (“conventional” agriculture)	16
1.3.2. No-till systems (“conservation” agriculture)	18
1.4. Conclusion	21
1.5. References	21
Chapter 2. The Biodiversity of Agricultural Soils	25
Laure Vieublé GONOD, Sophie JOIMEL and Audrey NIBOYET	
2.1. Soil organisms	25
2.2. Biodiversity of agricultural soils compared with other land uses	28

2.3. Effects of agricultural practices on soil biodiversity	29
2.3.1. Effects of mineral fertilizers.	30
2.3.2. Effects of the addition of exogenous organic matter	31
2.3.3. Effects of pesticides	35
2.3.4. Effects of tillage.	39
2.3.5. Effects of crop diversification.	41
2.4. Comparison of cropping systems	43
2.4.1. Organic farming versus conventional agriculture	44
2.4.2. Conservation agriculture versus conventional agriculture	46
2.4.3. Organic farming versus conservation agriculture	47
2.5. Soil biodiversity management – keys for promoting action	47
2.5.1. Bioindicators.	47
2.5.2. Link between biodiversity and soil functioning	48
2.5.3. Ecological engineering.	49
2.6. Conclusion	50
2.7. References	50

Chapter 3. Spatial Variability and Mapping of Agricultural Soils

63

Jean-Marc GILLIOT

3.1. Introduction.	63
3.2. Background: the origins of soil mapping in France	65
3.3. The digital age, from paper maps to spatialized databases: the available information for soil mapping	67
3.3.1. Augerholes, pits and soil analyses	67
3.3.2. The accessible French databases	67
3.3.3. The available international databases	70
3.3.4. Auxiliary cartographic data	71
3.4. Some of the general concepts and methods of soil mapping	74
3.4.1. The concepts of scale, resolution and sampling	74
3.4.2. Notions of regionalized variable and support: spatial organization of soil information	76
3.4.3. Changes to soil information support formats	77
3.4.4. Pedotransfer functions	81
3.5. Examples of uses of soil maps.	81
3.5.1. Precision agriculture using drones	81
3.5.2. Modeling of ammonia emissions arising from agricultural fertilization	85
3.6. References	87

Chapter 4. Runoff and Soil Erosion	91
Philippe MARTIN	
4.1. Preliminary considerations	91
4.1.1. Forms of erosion	91
4.1.2. Connections with human activity	92
4.1.3. Regulations put in place	92
4.2. The essential processes at work on agricultural land	93
4.2.1. Runoff	94
4.2.2. Sediment loads	95
4.3. Impact of agricultural activities on processes	98
4.3.1. Effects of cropping systems	98
4.3.2. Past and current long-term dynamics	101
4.4. Toward integrated watershed management	102
4.4.1. Limiting concentration levels flowing toward the talwegs	103
4.4.2. Sustainable protection of the talwegs	104
4.4.3. Reducing vulnerability in downstream agricultural territories	105
4.4.4. Population protection measures	105
4.5. The art of avoiding recipes	106
4.6. References	107
Chapter 5. Soils and Agricultural Land Property: Legal Aspects of Sectoral and Functional Protection	109
Louis DE REDON	
5.1. Soil, a physical environment like no other?	109
5.2. Soils are covered by the law as a biological environment	112
5.2.1. The legal foundations of soil protections	112
5.2.2. The legal protection of soils	115
5.3. Soils are covered by the law as a property right	119
5.3.1. The legal foundations of agricultural land ownership	119
5.3.2. The legal protection of agricultural land	124
5.4. Toward a global protection of physical environments?	128
Chapter 6. Methods for Estimating the Agronomic Value of Soils	131
Joël MICHELIN	
6.1. Why evaluate the agronomic value or the cultural suitability of soils?	131

6.2. Soil functions for agricultural production	133
6.2.1. The soil provides physical support for the plants	133
6.2.2. Soil, a reservoir for air and water.	133
6.2.3. The soil: a source of nutrients.	134
6.3. Intrinsic properties and characteristics of soils	134
6.3.1. Characteristics that are relatively easy to obtain	134
6.3.2. The water reserve of the soil	136
6.3.3. Natural soil drainage	139
6.3.4. Aeration of the soil	140
6.3.5. Stock and availability of nutrients	141
6.3.6. Workability of the soil	143
6.3.7. Soil tillage	143
6.4. Extrinsic factors	144
6.4.1. Physical environment factors	144
6.4.2. Technical and socioeconomic factors	145
6.5. Evaluation of agricultural values	147
6.5.1. Different levels of approach.	147
6.5.2. Principles of evaluation and classification	148
6.6. Examples of observation and classification methods	154
6.6.1. Approach using field pedological surveys	154
6.6.2. Approach using soil maps and databases	154
6.7. Conclusion	156
6.8. References	157

Chapter 7. The Concept of Ecosystem Services and Its Application to Soil: Between Promises and Reality 161

David MONTAGNE, Ottone SCAMMACCA,
Christian WALTER and Isabelle COUSIN

7.1. Introduction.	161
7.2. A short history of Ecosystem Services: from inception to the international institutionalization of this concept	162
7.2.1. An emerging concept.	163
7.2.2. Development and spread of the concept.	164
7.2.3. Institutionalization and market entry.	164
7.2.4. What is the future of Ecosystem Services?	165
7.3. Definition and conceptualization of Ecosystem Services	166
7.3.1. Ecosystem Services: a product derived from ecological systems or a co-product of ecological and socioeconomic systems	166
7.3.2. Conceptualization using a cascade model.	167

7.3.3. Supply, flow and demand	169
7.4. Classification of Ecosystem Services.	170
7.4.1. Classification from the Millennium Ecosystem Assessment.	170
7.4.2. The CICES classification	174
7.5. The biophysical quantification of Ecosystem Services	175
7.5.1. What is to be quantified?	175
7.5.2. How to quantify services?	178
7.6. Mapping Ecosystem Services	186
7.6.1. What is to be mapped?	187
7.6.2. How to map?	187
7.7. Applying the concept of Ecosystem Services to the soil component of ecosystems	193
7.7.1. Soils have largely been forgotten about in ecosystems approaches	193
7.7.2. New conceptual frameworks to reposition soils within the cascade model	194
7.7.3. What definitions can be used for Ecosystem Services related to or obtained from soils?	195
7.7.4. Assessing and mapping soil-related Ecosystem Services: where are we at present?	196
7.8. Conclusion	197
7.9. Acknowledgments.	199
7.10. References.	200
Chapter 8. Mediterranean Agricultural Soils.	211
Emmanuelle VAUDOUR	
8.1. Introduction.	211
8.1.1. Physical and human frameworks and the pedogenesis process in Mediterranean regions	211
8.1.2. Zonality of Mediterranean soils.	215
8.2. Fersiallitic red soils	217
8.2.1. Definition and formation processes	217
8.2.2. Geographic distribution and notable sequences	223
8.2.3. Agronomic potential	227
8.3. Vertisols.	227
8.3.1. Definition and formation processes	228
8.3.2. Agronomic potential	229
8.4. Soils with limestone accumulations or Calcarisols.	229
8.4.1. Definition and formation processes	230
8.4.2. Geographic distribution and notable sequences	231

8.4.3. Agronomic potential	234
8.5. Salisols and Sodosols	235
8.5.1. Definition and formation processes	235
8.5.2. Geographic distribution and notable sequences	238
8.5.3. Agronomic potential	239
8.6. Conclusion	240
8.7. References	241

Chapter 9. Tropical Soils and Sustainable Management 249

Cécile QUANTIN and Thierry BECQUER

9.1. Introduction.	249
9.2. Tropical pedogenesis: dominated by geochemical weathering.	250
9.3. Typical profile and differentiation of horizons and pedological units.	252
9.4. Principal characteristics, diversity of tropical soils	254
9.5. Properties and agronomic consequences.	256
9.5.1. Mineralogical characteristics and exchange properties	256
9.5.2. Advanced weathering: nutrition deficiencies and aluminum toxicity	258
9.5.3. Abundance of Fe and Al oxides: implications for the availability of phosphorus.	261
9.6. The sustainable management of soils with high geochemical weathering: the role of organic matter in Ferralsols.	261
9.6.1. Organic matter and exchange properties	262
9.6.2. Organic matter and nutrient cycling	262
9.6.3. Organic matter and acidification/alkalinization of soils	264
9.6.4. Organic material and phosphorus availability	265
9.7. Conclusion	266
9.8. References	267

Chapter 10. Urban Agricultural Soil. 273

Sophie JOIMEL, Tania DE ALMEIDA and Baptiste GRARD

10.1. Introduction	273
10.2. Redeploying urban agriculture.	275
10.3. Urban soils: the basis of urban agriculture.	277
10.3.1. The large diversity in urban soils	277
10.3.2. Varied physicochemical properties.	279
10.3.3. Interesting biological properties.	283

10.4. Managing ecosystem services provided by urban soils	284
10.4.1. Ecosystem services – a definition.	284
10.4.2. Soils that serve many purposes	286
10.5. Toward decision-making tools.	289
10.6. Conclusion	290
10.7. References.	291
List of Authors	297
Index	301