

3826913  
3826901



# SOILS: THEIR PROPERTIES AND MANAGEMENT

Editors: P.E.V. Charman and B.W. Murphy

In association with the Department of  
Land and Water Conservation, New South Wales



LAND & WATER  
CONSERVATION

OXFORD  
UNIVERSITY PRESS

# Contents

List of Figures	viii	3.2.2 Plot Studies	46
List of Tables	x	3.2.3 Use of Radioactive Isotopes	49
List of Plates	xii	3.2.4 Occasional Observations	50
Contributors	xiv	3.2.5 Catchment Studies	51
Preface and Acknowledgments	xvi	3.2.6 Sediment Surveys of Reservoirs	53
		3.2.7 Erosion Rates Following Bushfires	53
		3.2.8 Rates of Wind Erosion	53
<b>Chapter 1 The Nature of Soil</b>	<b>1</b>	3.3 Conclusions	55
(B.W. Murphy)		Bibliography	55
1.1 Soil Formation	3		
1.1.1 Soil-forming Factors	3	<b>Chapter 4 Other Forms of Soil Degradation</b>	<b>59</b>
1.1.2 Episodes of Landscape and Soil Development	9	(P.E.V. Charman)	
1.1.3 Soil-forming Processes	10	4.1 Soil Salinisation	61
Bibliography	12	4.1.1 Irrigation Salinity	61
		4.1.2 Dryland Salinity	61
<b>Chapter 2 Forms of Erosion</b>	<b>13</b>	4.1.3 Urban Salinity	62
(C.J. Rosewell, R.J. Crouch, R.J. Morse, J.F. Leys, R.W. Hicks and R.J. Stanley)		4.2 Soil Fertility Decline	63
2.1 Water Erosion	16	4.2.1 Chemical Fertility Decline	63
2.1.1 General Water Erosion Processes	16	4.2.2 Soil Acidification	64
2.1.2 Major Types of Water Erosion	17	4.3 Soil Structural Degradation	65
2.2 Wind Erosion	26	4.3.1 Soil Structure and Cultivation	65
2.2.1 Processes of Wind Erosion	26	4.3.2 Soil Structure and Irrigation	65
2.2.2 Micro-topographical Forms of Wind Erosion	28	4.4 Acid Sulfate Soils	67
2.2.3 Aeolian Landforms	29	4.5 Soil Contamination	68
2.2.4 Movement of Nutrients and Chemicals on Sediments Moved by Wind Erosion	29	Bibliography	69
2.3 Mass Movement	30	<b>Chapter 5 The Soil Profile</b>	<b>70</b>
2.3.1 Causes of Mass Movement	31	(B.W. Murphy and C.L. Murphy)	
2.3.2 Classification of Forms of Mass Movement	31	5.1 Soil Profile Morphology	71
2.3.3 Soil Factors	32	5.2 Soil Description in the Field	73
2.4 Coastal Erosion	33	5.2.1 Choice of Site	73
2.4.1 Coastal Processes	33	5.2.2 Site Description	73
2.4.2 Coastal Dunes and Erosion	34	5.2.3 Preparation of the Soil Profile for Examination	74
Bibliography	36	5.2.4 Describing the Profile	74
		5.2.5 Soil Properties Described in the Examination of a Profile	75
<b>Chapter 3 Soil Formation and Erosion Rates</b>	<b>39</b>	5.2.6 Field Soil Tests	80
(K. Edwards and C. Zierholz)		5.2.7 Interpretation of Soil Morphological Data	81
3.1 Soil Formation Rates	40	Bibliography	82
3.1.1 Soil-forming Materials	40		
3.1.2 Soil Development and Weathering Rates	41	<b>Chapter 6 Systems of Soil Classification</b>	<b>83</b>
3.2 Soil Loss Rates	44	(B.W. Murphy and C.L. Murphy)	
3.2.1 Erosion and Soil Loss	44	6.1 Soil Classification Systems in Australia	84
		6.2 The Australian Soil Classification System (ASCS)	86

6.2.1	Origins and Foundations	86	8.5.1	Sodic and Dispersible Soils	146
6.2.2	Operation of the System	86	8.5.2	Hardsetting Surface Soils or Fragile, Light-textured Surface Soils	146
6.2.3	Key to Soil Orders	87	8.5.3	Self-mulching Soils	147
6.3	Great Soil Groups	90	8.5.4	Acid Surface Soils	147
6.3.1	Origins and Foundations	90	8.5.5	Acid Sulfate Soils	147
6.3.2	Operation of the System	90	8.5.6	Aggregated or Subplastic Clays	147
6.4	The Factual Key	90	8.5.7	Expansive Soils	147
6.4.1	Origins and Foundations	90	8.5.8	Saline Soils	147
6.4.2	Operation of the Factual Key	91	8.6	Major Soils and Land Use	148
6.4.3	Types of Soil Defined by the Factual Key	95	Bibliography		148
6.5	Soil Taxonomy	96	<b>Chapter 9 Soil Landscapes of New South Wales</b>		150
6.5.1	Origins and Foundations	96	(B.W. Murphy, D.J. Eldridge, D.J. McKane and J.M. Gray)		
6.5.2	Operation of the System	96	9.1	Soil Landscape Groups of the Eastern Zone	151
6.5.3	Soil Units of Soil Taxonomy	97	9.1.1	Soil Landscape Distribution	151
6.6	FAO/UNESCO Soil Classification System	98	9.1.2	Agricultural Productivity of Soil Landscapes	157
6.7	Numerical Classification	98	9.1.3	Soil Landscapes and Soil Conservation	159
6.7.1	Origins and Foundations	98	9.2	Soil Landscape Groups of the Western Zone	159
6.7.2	Operation of the System	99	9.2.1	Soil Landscape Distribution	160
6.8	Soil Classification for Sustainable Soil Management	101	9.2.2	Soil Management	163
6.8.1	General Considerations	101	Bibliography		165
6.8.2	Soil Classification System for Western New South Wales	103	<b>Chapter 10 Soil Physical Properties</b>		166
Bibliography		105	(G.W. Geeves, B. Craze and G.J. Hamilton)		
<b>Chapter 7 Soil Survey and Mapping</b>		106	10.1	Soil Texture	168
(G.A. Chapman and G. Atkinson)			10.1.1	Particle Size Analysis Methods	168
7.1	General Principles	107	10.1.2	Expressing Particle Size Data	170
7.1.1	Literature Review	107	10.1.3	Field Approximation of Soil Texture/Field Texture Grades	170
7.1.2	The Purpose of Soil Survey	108	10.1.4	Inferring Soil Properties from Soil Texture	171
7.1.3	Soil Entities and Soil Classification	110	10.2	Clay Mineralogy	173
7.1.4	Soil Mapping Procedures	112	10.3	Soil Structure	174
7.2	General Purpose Soil Mapping	118	10.3.1	Soil Structural Form	174
7.2.1	Land Systems Mapping	118	10.3.2	Soil Structural Stability	176
7.2.2	Soil Landscape Mapping	119	10.3.3	Application of the Emerson Aggregate Test and its Derivatives	179
7.2.3	Derivative Map Products	124	10.3.4	Soil Structural Resilience	180
7.2.4	Numerical Methods in Soil Landscape Mapping	125	10.3.5	Cultural Practices Affecting Soil Structure	180
7.3	Special Purpose Soil Mapping	125	10.4	Soil Water Retention and Pore Space	180
7.3.1	Soil Survey Interpretation for Rural Capability	125	10.4.1	Available-Water Storage Capacity (AWSC)	181
7.3.2	Soil Survey Interpretation for Urban Capability	126	10.5	Soil Permeability	183
Bibliography		129	10.5.1	Hydraulic Conductivity	183
<b>Chapter 8 Soils of New South Wales</b>		133	10.6	Soil Water Movement	185
(B.W. Murphy, D.J. Eldridge, G.A. Chapman and D.J. McKane)			10.6.1	Infiltration and Runoff under Rainfall	185
8.1	Soils of the Eastern Zone	134	10.7	Soil Strength, Friability and Penetration Resistance	187
8.1.1	Major Soils	134			
8.2	Soils of the Western Zone	140			
8.2.1	Major Soils	140			
8.3	Factors Affecting the Distribution of Soils	142			
8.4	Fertility of New South Wales Soils	143			
8.5	Special Soil Groups	146			

10.7.1 Penetration Resistance	187	<b>Chapter 13 Soil Chemical Properties</b>	221
10.7.2 Soil Strength and Modulus of Rupture	187	13.1 Cation Exchange Capacity (P.E.V. Charman)	222
10.7.3 Friability	187	13.2 Soil Acidification (G. Fenton and K.R. Helyar)	223
10.8 Appropriate Methods, Sampling and Interpretation	188	13.2.1 The Process of Acidification	224
Bibliography	188	13.2.2 Causes and Control of Agriculturally Induced Soil Acidity	226
<b>Chapter 11 Soil Engineering Properties</b> (R.W. Hicks)	190	13.2.3 Soil Acidity and Plant Growth	229
11.1 Soil Composition— Particle Size Distribution	191	13.2.4 Practical Options for Managing Acid Soils	233
11.2 Soil Plasticity.	192	13.2.5 Using Lime	234
11.3 Unified Soil Classification System (USCS)	194	13.3 Soil Salinisation (P.E.V. Charman and A.C. Wooldridge)	237
11.3.1 Classifying a Soil Material— Laboratory Method	194	13.3.1 Causes of Soil Salinity	237
11.3.2 Classifying a Soil Material— Field Method	196	13.3.2 Effects of Soil Salinity	240
11.3.3 Soil Components and Their Properties	197	13.3.3 Recognition of Soil Salinity	242
11.3.4 Allocating a Soil in the USCS	198	13.3.4 Management of Saline Soils	243
11.4 Soil Shrink-Swell Properties	200	13.4 Soil Nutrient Decline (P.E.V. Charman)	245
11.4.1 Expansive Soils in New South Wales	200	13.4.1 Chemical Fertility Decline	246
11.4.2 Shrinkage and Swelling Processes	201	13.4.2 Nutrient Requirements for Plant Growth	247
11.4.3 Identifying Expansive Soils	201	13.5 Acid Sulfate Soils (M.D. Melville and I. White)	249
11.5 Other Soil Properties and Their Effect on Soil Engineering Properties	203	13.5.1 What Are Acid Sulfate Soils?	249
11.5.1 Acid Sulfate Soils	203	13.5.2 Origin of Potential Acid Sulfate Soils	250
11.5.2 Saline Soils	203	13.5.3 The Formation of Actual Acid Sulfate Soils	250
11.5.3 Soil Erodibility	203	13.5.4 The Role of Land Drainage	251
Bibliography	203	13.5.5 Management of Acid Sulfate Soils	251
<b>Chapter 12 Soil Erodibility</b> (G.W. Geeves and J.F. Leys)	205	13.6 Toxicities in Soils (P.J. Mulvey and G.L. Elliott)	252
12.1 Soil Erodibility to Water	206	13.6.1 Metal Toxicities	254
12.1.1 Effects of Soil Erodibility on Water Erosion Hazard	206	13.6.2 Organic Materials	255
12.1.2 Inter-rill Erosion under Rainfall	206	13.6.3 Salt Toxicity	256
12.1.3 Rill and Gully Erosion	207	13.6.4 Land Use and Soil Pollution	256
12.1.4 Tunnel Erosion	207	13.6.5 Critical Toxic Limits	257
12.1.5 Inherent Soil Properties Affecting Erodibility	207	Bibliography	257
12.1.6 Assessing Erodibility Using Field Observations	209	<b>Chapter 14 Soil Organic Matter</b> (P.E.V. Charman and M.M. Roper)	260
12.1.7 Erodibility Parameters in Soil Erosion Models	209	14.1 Composition of Soil Organic Matter	261
12.1.8 Using Soil Erodibility Assessments and Measurements	212	14.2 The Role of Soil Organic Matter 14.2.1 Greenhouse Gas Control	262
12.2 Soil Erodibility to Wind	213	14.3 The Effect of Organic Matter on Crop Production	264
12.2.1 Erodibility—the Concept	213	14.4 Soil Improvement	265
12.2.2 Erodibility—the Practice	214	14.4.1 Increasing Soil Organic Matter	265
12.2.3 Measures of Erodibility	215	14.4.2 Crop Residue Breakdown	266
12.2.4 Erodibility Scale	217	14.4.3 Crop Rotations	267
Bibliography	218	14.5 Agricultural Practices and Soil Organic Matter	268
		14.6 Soil Organic Matter and Soil Conservation	269
		Bibliography	269

<b>Chapter 15 Soils, Vegetation and Land Use</b>	271	17.2 Soil-Vegetation Relations	321
(R.O. Sonter, W.S. Semple and J.W. Lawrie)		17.2.1 Patchiness and Resource Redistribution	321
15.1 Soils and Vegetation	272	17.2.2 Vegetation Distribution in Relation to Soils	321
15.1.1 Soil Types and Vegetation Types	272	17.3 Soil Biota in Rangelands	322
15.1.2 Relationship Between Soils and Vegetation	272	17.4 Measuring the Productive Potential of Soils	323
15.1.3 Conclusion	277	17.5 Erosion Processes in Rangelands	323
15.2 Rural Land Capability	278	17.5.1 Water and Wind Erosion	324
15.2.1 Rural Land Capability Assessment	279	17.5.2 Vegetation: the Key to Erosion Prevention	324
15.2.2 Land Capability Classes	281	17.6 Reclaiming Rangeland Soils	325
15.2.3 Soils and Rural Land Capability	281	17.6.1 Reclamation by Reducing Total Grazing Pressure	325
15.3 The Effects of Soils on Land Use	284	17.6.2 Reclamation by Mechanical Methods	325
Bibliography	286	17.7 Management of Rangeland Soils	326
<b>Chapter 16 Soils and Sustainable Farming Systems</b>	287	17.7.1 Grazing and Fire	326
(J.W. Lawrie, B.W. Murphy, I.J. Packer and A.J. Harte)		17.7.2 Management Strategies to Prevent Degradation	326
16.1 Development of Sustainable Farming Systems	288	Bibliography	327
16.1.1 Historical Review	288	<b>Chapter 18 Soils and Coastal Dune Management</b>	328
16.1.2 The Current Situation	289	(P.A. Conacher and R.J. Stanley)	
16.1.3 The Areas Involved	290	18.1 Coastal Dune Soils	329
16.1.4 Dryland Cropping Systems in New South Wales	290	18.1.1 Soil Characteristics	329
16.2 Conservation Farming—Field Practice	292	18.1.2 Soil Types	330
16.2.1 Practical Issues in Applying Conservation Tillage	292	18.2 Coastal Dune Vegetation	332
16.2.2 Conservation Farming in the Whole Farm Operation	296	18.3 Coastal Land Use	332
16.2.3 Future Trends in Farming Practice	296	18.3.1 Urban and Residential Development	332
16.3 The Effects of Dryland Cropping on Soil Degradation	297	18.3.2 Recreational Use	333
16.3.1 Changes in Soil Organic Matter	298	18.3.3 Heavy Mineral Mining and Sand Extraction	333
16.3.2 Soil Physical Properties	299	18.3.4 Grazing	333
16.3.3 Runoff and Soil Loss	300	18.3.5 Effluent Disposal	333
16.3.4 Soil Compaction	303	18.4 Techniques of Dune Rehabilitation	334
16.3.5 Changing Soil Structure	303	18.4.1 The Process of Dune Stabilisation	334
16.3.6 Consequences of Soil Structure Degradation	304	18.4.2 Stabilising the Dunal Barrier	334
16.4 Management of Soil Structure	305	18.4.3 Long-term Management and Maintenance	334
16.4.1 Depth Zones for Soil Structure Management	305	Bibliography	335
16.4.2 Specific Functions of Soil Structure	306	<b>Chapter 19 Soils and Revegetation</b>	336
16.4.3 Cropping Systems and Soil Structure	307	(W.H. Johnston)	
16.4.4 Soil Types in Relation to Soil Structure Management	307	19.1 Plants and Soil in Perspective	337
16.5 Conclusion	312	19.2 Plants and the Hydrologic Cycle	337
Bibliography	312	19.3 Agricultural Development and Land Degradation	339
<b>Chapter 17 Soils and Rangeland Management</b>	318	19.4 Planning a Revegetation Program	339
(D.J. Eldridge)		19.4.1 Aims and Objectives	339
17.1 Introduction to Rangeland Soils	319	19.4.2 Revegetation Species	340
		19.4.3 Site Investigations	340
		19.4.4 Seed Mixtures	342

19.4.5 Sowing Time	342	21.1.3 Soil Erodibility	379
19.4.6 Fertilisers	342	21.1.4 Soil Drainage and Depth	380
19.4.7 Site Preparation	343	21.1.5 Soil Salinity	381
19.4.8 Soil Factors Affecting Revegetation	344	21.1.6 Other Problem Soils	381
19.5 Sward Improvement and Management	346	21.2 Treatment Measures	382
19.5.1 Strategic Grazing	346	21.2.1 Mass Movement	382
19.5.2 Oversowing	347	21.2.2 Expansive Soils	383
19.6 Sustainable Grazing Management	348	21.2.3 Soil Erodibility	383
Bibliography	349	21.2.4 Soil Drainage	383
		21.2.5 Soil Salinity	384
<b>Chapter 20 Soils and Their Use for Earthworks</b>	<b>350</b>	21.3 Urban Planning	384
(R. J. Crouch, K. C. Reynolds, R. W. Hicks and D. A. Greentree)		21.3.1 Change from Rural to Urban Use	384
20.1 Design of Earthworks	351	21.3.2 Urban Capability Classification	384
20.1.1 Runoff	352	21.4 Waste Application to Soils	386
20.1.2 Channel Erodibility	352	21.4.1 Potential Impacts on Soils	386
20.1.3 Soil Permeability	354	21.4.2 Properties of Waste Products	387
20.1.4 Bank Stability	354	21.4.3 Conditions Where Wastes Should Not Be Applied	388
20.1.5 Bank Spacing	356	21.4.4 Acceptable Application Rates	388
20.2 Construction of Earthworks	357	21.4.5 Salinity and Sodicity of Waste Products	388
20.2.1 Soil Sampling for Earthworks	357	21.4.6 Soil and Land Management	389
20.2.2 Field Testing	358	Bibliography	389
20.2.3 Laboratory Testing	358		
20.2.4 Recommendations from Soil Test Data	360	<b>Chapter 22 Soils and Extractive Industries</b>	<b>390</b>
20.2.5 Practical Considerations	365	(G. L. Elliott and K. C. Reynolds)	
20.2.6 Soil Compaction	365	22.1 Importance of Natural Topsoil	391
20.2.7 Soil Amelioration	369	22.2 Alternative Topdressing Materials	392
20.3 Sealing Leaking Structures	370	22.2.1 Soil Attributes for Topdressing	392
20.3.1 Finding the Leak	370	22.2.2 Handling Topdressing Material	395
20.3.2 Should the Leaking Structure Be Repaired?	370	Bibliography	396
20.3.3 Sealing Structures Without Drainage	371		
20.3.4 Sealing Methods Requiring Drainage	371	<b>Chapter 23 Soils and Sustainable Development — a Concluding Perspective</b>	<b>398</b>
20.4 Soil Drainage	373	(P. E. V. Charman)	
20.4.1 Soil Drainage and Soil Type	373	23.1 Soil Degradation and Productivity	400
20.4.2 Problems Associated with Poor Soil Drainage	374	23.2 Soils and Catchment Health	402
20.4.3 Factors Contributing to Poor Soil Drainage	375	23.3 Conclusion	403
20.4.4 Treatment of Drainage Problems	375	Bibliography	404
Bibliography	376		
<b>Chapter 21 Soils and Urban Land Use</b>	<b>378</b>	<b>Appendix 1 Broad Correlation between Australian Soil Classifications and the US Soil Taxonomy</b>	<b>405</b>
(R. W. Hicks and C. Hird)		<b>Appendix 2 Identification of Soil Groups</b>	<b>408</b>
21.1 Soils and Construction Practice	379	<b>Appendix 3 Glossary of Soil Science Terms</b>	<b>413</b>
21.1.1 Mass Movement	379	<b>Index</b>	<b>441</b>
21.1.2 Expansive Soils	379		