

THE NATURE AND PROPERTIES OF SOILS

1860

1860

THE NATURE AND
PROPERTIES OF
SOILS *8th Edition*

NYLE C. BRADY

Professor of Soil Science

New York State College of Agriculture and Life Science

Cornell University

and Director, International Rice Research Institute,

Philippines

MACMILLAN PUBLISHING CO., INC.

New York

COLLIER MACMILLAN PUBLISHERS,

London

COPYRIGHT © 1974, MACMILLAN PUBLISHING CO., INC.

PRINTED IN THE UNITED STATES OF AMERICA

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the Publisher.

Earlier editions by T. Lyttleton Lyon and Harry O. Buckman copyright 1922, 1929, 1937, and 1943 by Macmillan Publishing Co., Inc. Earlier editions by Harry O. Buckman and Nyle C. Brady copyright 1952, © 1960, and copyright © 1969 by Macmillan Publishing Co., Inc. Copyright renewed 1950 by Bertha C. Lyon and Harry O. Buckman, 1957 and 1965 by Harry O. Buckman, 1961 by Rita S. Buckman.

MACMILLAN PUBLISHING CO., INC.
866 Third Avenue, New York, New York 10022
COLLIER-MACMILLAN CANADA, LTD.

Library of Congress Cataloging in Publication Data

Brady, Nyle C

The nature and properties of soils.

Sixth-7th ed. by H. O. Buckman and N. C. Brady.

I. Soil science. I. Buckman, Harry Oliver,
(date) The nature and properties of soils.

II. Title.

S591.B79 1974 631.4 73-1046

ISBN 0-02-313350-3

Printing: 1 2 3 4 5 6 7 8

Year: 4 5 6 7 8

PREFACE

CHANGE is the name of the game in modern soil science. Not only have new discoveries dictated subject matter changes but society has forced changes by demanding solutions to pressing human problems. In addition, teaching methods have become more informal. Students are increasingly involved in independent study, each student being given an opportunity to move at his or her pace. Simultaneously, the science background of college students has broadened, which makes it easier for them to comprehend the constitution of soils and the biological, chemical, and physical processes occurring in soils. The changes made in this eighth edition reflect both increased knowledge of soils and the use of this knowledge to solve emerging societal problems.

Growing knowledge of and concern for environmental pollution have dictated major changes from previous editions. Soil is being used more and more as a recipient of organic and inorganic wastes from both the farm and the city. These wastes include pesticides, animal manures, industrial chemicals, domestic sewage, and nuclear contaminants. Their effects on soil processes and properties and on plants grown in these soils are a public as well as a scientific concern.

This eighth edition responds to the concern for the soil as a recipient of wastes in two ways. First, a new chapter on soil pollutants has been added. This chapter provides a general discussion of the pollutants, their reactions in soils, and their effects on soil organisms including plants. Second, the chapter on animal manures has been rewritten to reflect changes in the concepts of animal wastes in modern agriculture, and other chapters, such as those concerned with the loss of nutrients from soils, have been revised to take into account aspects concerned with environmental quality.

Another marked change over previous editions relates to the treatment of soil water. In recent years, scientists have developed a unified energy concept of water as it enters and moves in soils, is absorbed and translocated through plants, and is finally evaporated from the leaves into the atmosphere. This concept of a soil-plant-atmosphere continuum (SPAC) is the basis for major changes in the three chapters on soil moisture. The energy relations of water as it moves through the SPAC have been presented in terms easily understood by students having their initial exposure to soils.

The introductory chapter has been expanded to include a glimpse of the historical development of soil science. Similarly, some historical perspective of the evolution of current concepts of soil classification is included in Chapter 12. The comprehensive classification system of the U.S. Department of Agriculture is emphasized, only general reference being made to other systems.

Minor revisions have been made in all chapters of the book. The treatment of soil organisms and organic matter has been brought up to date. Chapter 13 has been revised to incorporate the new comprehensive classification system as it relates to organic soils.

The readability of the text has been improved by reducing the number of footnotes and by placing references at the ends of chapters rather than at the bottoms of pages and in figures and tables. Changes were made to reduce the formality of expression throughout the text, and many new figures and tables have been added.

The author is indebted to the many soil scientists who made suggestions for improving the text; to his wife, Martha, for typing, proofreading, and checking references; to Frances Geherin of his office for editing the manuscript; and to Patricia Oplinger, Roberta Reniff, Grace Saatman, and Mildred Townsley for typing it.

N. C. B.

CONTENTS

1.	The Soil in Perspective	1
1:1	What Is Soil?	2
1:2	Evaluation of Modern Concepts of Soil	2
1:3	The Approach—Edaphological Versus Pedological	6
1:4	A Field View of Soil	7
1:5	The Soil Profile	9
1:6	Subsoil and Surface Soil	10
1:7	Mineral (Inorganic) and Organic Soils	11
1:8	General Definition of Mineral Soils	12
1:9	Four Major Components of Soils	12
1:10	Mineral (Inorganic) Constituents in Soils	13
1:11	Soil Organic Matter	14
1:12	Soil Water—A Dynamic Solution	15
1:13	Soil Air—Also a Changeable Constituent	16
1:14	The Soil—A Tremendous Biological Laboratory	17
1:15	Clay and Humus—The Seat of Soil Activity	18
2.	Supply and Availability of Plant Nutrients in Mineral Soils	19
2:1	Factors Controlling the Growth of Higher Plants	19
2:2	The Essential Elements	20
2:3	Essential Elements from Air and Water	20
2:4	Essential Elements from the Soil	21
2:5	Macronutrient Contents of Mineral Soils	23
2:6	Forms of Macronutrients in Soils	26
2:7	Transfer of Plant Nutrients to Available Forms	29
2:8	Soil Solution	32
2:9	Nutritional Importance of Soil pH	35
2:10	Forms of Elements Used by Plants	35
2:11	Soil and Plant Interrelations	37
2:12	Soil Fertility Inferences	38
3.	Some Important Physical Properties of Mineral Soils	40
3:1	Classification of Soil Particles and Mechanical Analysis	40
3:2	Physical Nature of the Soil Separates	42
3:3	Mineralogical and Chemical Compositions of the Soil Separates	44
3:4	Soil Textural Classes	45

3:5	Determination of Soil Class	48
3:6	Particle Density of Mineral Soils	49
3:7	Bulk Density of Mineral Soils	50
3:8	Pore Space of Mineral Soils	53
3:9	Structure of Mineral Soils	55
3:10	Aggregation and Its Promotion in Arable Soils	58
3:11	Structural Management of Soils	62
3:12	Soil Consistence	64
3:13	Tilth and Tillage	66
4.	Soil Colloids: Their Nature and Practical Significance	71
4:1	General Constitution of Silicate Clays	71
4:2	Adsorbed Cations	75
4:3	Fundamentals of Silicate Clay Structure	76
4:4	Mineralogical Organization of Silicate Clays	78
4:5	Source of the Negative Charge on Silicate Clays	83
4:6	Chemical Composition of Silicate Clays	86
4:7	Genesis of Silicate Clays	88
4:8	Mineral Colloids Other Than Silicates	91
4:9	Geographic Distribution of Clays	92
4:10	Organic Soil Colloids—Humus	94
4:11	Colloids—Acid Salts	96
4:12	Cation Exchange	97
4:13	Cation Exchange Capacity	99
4:14	Cation Exchange Capacity of Whole Soils	103
4:15	Percentage Base Saturation of Soils	103
4:16	Cation Exchange and the Availability of Nutrients	105
4:17	Other Properties of Colloids—Plasticity, Cohesion, Swelling, Shrinkage, Dispersion, and Flocculation	106
4:18	Conclusion	109
5.	Organisms of the Soils	111
5:1	Organisms in Action	111
5:2	Organism Numbers, Biomass, and Metabolic Activity	114
5:3	Earthworms	116
5:4	Soil Microanimals	118
5:5	Roots of Higher Plants	121
5:6	Soil Algae	123
5:7	Soil Fungi	123
5:8	Soil Actinomycetes	126
5:9	Soil Bacteria	128
5:10	Conditions Affecting the Growth of Soil Bacteria	129

5:11	Injurious Effects of Soil Organisms on Higher Plants	130
5:12	Competition Among Soil Microorganisms	132
5:13	Effects of Agricultural Practice on Soil Organisms	133
5:14	Activities of Soil Organisms Beneficial to Higher Plants	135
6.	Organic Matter of Mineral Soils	137
6:1	Sources of Soil Organic Matter	137
6:2	Composition of Plant Residues	137
6:3	Decomposition of Organic Compounds	139
6:4	Energy of Soil Organic Matter	142
6:5	Simple Decomposition Products	143
6:6	The Carbon Cycle	143
6:7	Simple Products Carrying Nitrogen	145
6:8	Simple Products Carrying Sulfur	146
6:9	Mineralization of Organic Phosphorus	146
6:10	Humus—Genesis and Definition	146
6:11	Humus—Nature and Characteristics	148
6:12	Direct Influence of Organic Compounds on Higher Plants	150
6:13	Influence of Soil Organic Matter on Soil Properties	150
6:14	Carbon–Nitrogen Ratio	151
6:15	Significance of the Carbon–Nitrogen Ratio	151
6:16	Amount of Organic Matter and Nitrogen in Soils	154
6:17	Factors Affecting Soil Organic Matter and Nitrogen	156
6:18	Regulation of Soil Organic Matter	161
7.	Soil Water: Characteristics and Behavior	164
7:1	Structure and Related Properties of Water	164
7:2	Soil Water Energy Concepts	167
7:3	Soil Moisture Content Versus Suction	173
7:4	Measuring Soil Moisture	175
7:5	Capillary Fundamentals as They Relate to Soil Water	178
7:6	Types of Soil Water Movement	181
7:7	Saturated Flow Through Soils	182
7:8	Unsaturated Flow in Soils	184
7:9	Water Movements in Stratified Soils	185
7:10	Water Vapor Movement	186
7:11	Retention of Soil Moisture in the Field	189
7:12	Conventional Soil Moisture Classification Schemes	192
7:13	Factors Affecting Amount and Use of Available Soil Moisture	195
7:14	How Plants Are Supplied with Water—Capillarity and Root Extension	197
7:15	Conclusion	199

8.	Vapor Losses of Soil Moisture and Their Regulation	200
8:1	Interception of Rain Water by Plants	200
8:2	The Soil–Water–Plant Continuum	202
8:3	Evapo-transpiration	204
8:4	Magnitude of Evaporation Losses	207
8:5	Efficiency of Water Use	208
8:6	Evaporation Control: Mulches and Cultivation	210
8:7	Vaporization Control in Humid Regions	215
8:8	Vaporization Control in Semiarid and Subhumid Regions	215
8:9	Evaporation Control of Irrigated Lands	216
9.	Liquid Losses of Soil Water and Their Control	220
9:1	Percolation and Leaching—Methods of Study	220
9:2	Percolation Losses of Water	221
9:3	Leaching Losses of Nutrients	223
9:4	Land Drainage	227
9:5	Open Ditch Drainage	228
9:6	Tile Drains	229
9:7	Benefits of Land Drainage	232
9:8	Runoff and Soil Erosion	234
9:9	Accelerated Erosion—Mechanics	236
9:10	Accelerated Erosion—Causes and Rate Factors	237
9:11	Types of Water Erosion	240
9:12	Sheet and Rill Erosion—Losses Under Regular Cropping	240
9:13	Sheet and Rill Erosion—Methods of Control	243
9:14	Gully Erosion and Its Control	245
9:15	Wind Erosion—Its Importance and Control	245
9:16	Conservation Treatment Needs in the United States	251
9:17	Summary of Soil Moisture Regulation	251
10.	Soil Air and Soil Temperature	253
10:1	Soil Aeration Defined	253
10:2	Soil Aeration Problems in the Field	254
10:3	Composition of Soil Air	256
10:4	Factors Affecting the Composition of Soil Air	258
10:5	Effects of Soil Aeration on Biological Activities	260
10:6	Other Effects of Soil Aeration	264
10:7	Aeration in Relation to Soil and Crop Management	265
10:8	Soil Temperature	266
10:9	Absorption and Loss of Solar Energy	268

10:10	Specific Heat of Soils	270
10:11	Heat of Vaporization	271
10:12	Movement of Heat in Soils	272
10:13	Soil Temperature Data	272
10:14	Soil Temperature Control	274
11.	Origin, Nature, and Classification of Parent Materials	277
11:1	Classification and Properties of Rocks	277
11:2	Weathering—A General Case	279
11:3	Mechanical Forces of Weathering	281
11:4	Chemical Processes of Weathering	282
11:5	Factors Affecting Weathering of Minerals	285
11:6	Weathering in Action—Genesis of Parent Materials	287
11:7	Geological Classification of Parent Materials	287
11:8	Residual Parent Material	288
11:9	Colluvial Debris	290
11:10	Alluvial Stream Deposits	290
11:11	Marine Sediments	292
11:12	The Pleistocene Ice Age	293
11:13	Glacial Till and Associated Deposits	295
11:14	Glacial Outwash and Lacustrine Sediments	298
11:15	Glacial-Aeolian Deposits	299
11:16	Agricultural Significance of Glaciation	300
12.	Soil Formation, Classification, and Survey	303
12:1	Factors Influencing Soil Formation	303
12:2	Weathering and Soil Profile Development	310
12:3	The Soil Profile	312
12:4	Concept of Individual Soils	315
12:5	Soil Classification in the United States	317
12:6	Soil Classification—New Comprehensive System	318
12:7	Soil Orders	322
12:8	Soil Suborders, Great Groups, and Subgroups	333
12:9	Soil Families, Series, Phases, Associations, and Catenas	337
12:10	Soil Classification—1949 System	340
12:11	Soil Survey and Its Utilization	343
12:12	Land Capability Classification	347
13.	Organic Soils (Histosols): Their Nature, Properties, and Utilization	353
13:1	Genesis of Organic Deposits	353
13:2	Area and Distribution of Peat Accumulations	355

13:3	Peat Parent Materials	356
13:4	Uses of Peat	358
13:5	Classification of Organic Soils	359
13:6	Physical Characteristics of Field Peat Soils	361
13:7	Colloidal Nature of Organic Soils	362
13:8	Chemical Composition of Organic Soils	364
13:9	Bog Lime—Its Importance	367
13:10	Factors That Determine the Value of Peat and Muck Soils	367
13:11	Preparation of Peat for Cropping	368
13:12	Management of Peat Soils	368
13:13	Organic Versus Mineral Soils	370
14.	Soil Reaction: Acidity and Alkalinity	372
14:1	Source of Hydrogen Ions	372
14:2	Colloidal Control of Soil Reaction	378
14:3	Major Changes in Soil pH	379
14:4	Minor Fluctuations in Soil pH	381
14:5	Hydrogen Ion Heterogeneity of the Soil Solution	381
14:6	Active Versus Exchange Acidity	382
14:7	Buffering of Soils	384
14:8	Buffer Capacity of Soils and Related Phases	385
14:9	Importance of Buffering	386
14:10	Soil-Reaction Correlations	387
14:11	Relation of Higher Plants to Soil Reaction	391
14:12	Determination of Soil pH	393
14:13	Soil Acidity Problems	394
14:14	Methods of Intensifying Soil Acidity	395
14:15	Reaction of Soils of Arid Regions	396
14:16	Reaction of Saline and Sodic Soils	396
14:17	Growth of Plants on Halomorphic Soils	399
14:18	Tolerance of Higher Plants to Halomorphic Soils	399
14:19	Management of Saline and Sodic Soils	400
14:20	Conclusion	402
15.	Lime and Its Soil-Plant Relationships	404
15:1	Liming Materials	404
15:2	Chemical Guarantee of Liming Materials	406
15:3	Fineness Guarantee of Limestone	409
15:4	Changes of Lime Added to the Soil	410
15:5	Loss of Lime from Arable Soils	412
15:6	Effects of Lime on the Soil	413
15:7	Crop Response to Liming	414

15:8	Overliming	415
15:9	Shall Lime Be Applied?	415
15:10	Form of Lime to Apply	416
15:11	Amounts of Lime to Apply	417
15:12	Methods of Applying Lime	420
15:13	Lime and Soil Fertility Management	421
16.	Nitrogen and Sulfur Economy of Soils	422
16:1	Influence of Nitrogen on Plant Development	422
16:2	Forms of Soil Nitrogen	423
16:3	The Nitrogen Cycle	423
16:4	Ammonia Fixation	427
16:5	Nitrification	428
16:6	Soil Conditions Affecting Nitrification	429
16:7	Fate of Nitrate Nitrogen	431
16:8	Gaseous Losses of Soil Nitrogen	431
16:9	Fixation of Atmospheric Nitrogen by Legume Bacteria	434
16:10	Amount of Nitrogen Fixed by Legume Bacteria	436
16:11	Fate of Nitrogen Fixed by Legume Bacteria	437
16:12	Do Legumes Always Increase Soil Nitrogen?	437
16:13	Fixation by Organisms in Symbiosis with Nonlegumes	438
16:14	Nonsymbiotic Fixation of Atmospheric Nitrogen	439
16:15	Amount of Nitrogen Fixed by Nonsymbiosis	440
16:16	Addition of Nitrogen to Soil in Precipitation	441
16:17	Reactions of Nitrogen Fertilizers	441
16:18	Practical Management of Soil Nitrogen	443
16:19	Importance of Sulfur	444
16:20	Natural Sources of Sulfur	446
16:21	The Sulfur Cycle	449
16:22	Behavior of Sulfur Compounds in Soils	449
16:23	Sulfur and Soil Fertility Maintenance	453
17.	Supply and Availability of Phosphorus and Potassium	456
17:1	Importance of Phosphorus	456
17:2	Influence of Phosphorus on Plants	457
17:3	The Phosphorus Problem	457
17:4	Phosphorus Compounds in Soils	458
17:5	Factors That Control the Availability of Inorganic Soil Phosphorus	460
17:6	pH and Phosphate Ions	460
17:7	Inorganic Phosphorus Availability in Acid Soils	462

17:8	Inorganic Phosphorus Availability at High pH Values	466
17:9	pH for Maximum Inorganic Phosphorus Availability	466
17:10	Availability and Surface Area of Phosphates	467
17:11	Phosphorus-Fixing Power of Soils	468
17:12	Influence of Soil Organisms and Organic Matter on the Availability of Inorganic Phosphorus	469
17:13	Availability of Organic Phosphorus	469
17:14	Practical Control of Phosphorus Availability	470
17:15	Potassium—The Third “Fertilizer” Element	472
17:16	Effects of Potassium on Plant Growth	472
17:17	The Potassium Problem	473
17:18	Forms and Availability of Potassium in Soils	475
17:19	Factors Affecting Potassium Fixation in Soils	479
17:20	Practical Implications in Respect to Potassium	480
18.	Micronutrient Elements	484
18:1	Deficiency Versus Toxicity	484
18:2	Role of the Micronutrients	486
18:3	Source of Micronutrients	487
18:4	General Conditions Conducive to Micronutrient Deficiency	489
18:5	Factors Influencing the Availability of the Micronutrient Cations	490
18:6	Chelates	493
18:7	Factors Influencing the Availability of the Micronutrient Anions	496
18:8	Need for Nutrient Balance	498
18:9	Soil Management and Micronutrient Needs	499
19.	Fertilizers and Fertilizer Management	503
19:1	The Fertilizer Elements	503
19:2	Three Groups of Fertilizer Materials	503
19:3	Nitrogen Carriers—Two Groups	504
19:4	Inorganic Nitrogen Carriers	504
19:5	Phosphatic Fertilizer Materials	510
19:6	Fertilizer Materials Carrying Potassium	513
19:7	Sulfur in Fertilizers	515
19:8	Micronutrients	515
19:9	Mixed Fertilizers	517
19:10	Effect of Mixed Fertilizers on Soil pH	520
19:11	The Fertilizer Guarantee	520
19:12	Fertilizer Inspection and Control	521
19:13	Fertilizer Economy	522

19:14	Movement of Fertilizer Salts in the Soil	524
19:15	Methods of Applying Solid Fertilizers	525
19:16	Application of Liquid Fertilizers	526
19:17	Factors Influencing the Kind and Amount of Fertilizers to Apply	527
19:18	Kind of Crop to Be Fertilized	528
19:19	Chemical Condition of the Soil—Total Versus Partial Analyses	529
19:20	Tests for Available Soil Nutrients—Quick Tests	530
19:21	Broader Aspects of Fertilizer Practice	531
20.	Animal Manures and Green Manures	534
20:1	Quantity of Manure Produced	534
20:2	Chemical Composition	538
20:3	Storage, Treatment, and Management of Animal Manures	541
20:4	Utilization of Animal Manures	544
20:5	Long-Term Effects of Manures	546
20:6	Green Manures—Defined	546
20:7	Benefits of Green Manures	546
20:8	Plants Suitable as Green Manures	548
20:9	Problems with Green Manures	549
20:10	Practical Utilization of Green Manures	550
21.	Soils and Chemical Pollution	551
21:1	Chemical Pesticides—Background	551
21:2	Kinds of Pesticides	553
21:3	Behavior of Pesticides in Soils	554
21:4	Effects of Pesticides on Soil Organisms	559
21:5	Contamination with Toxic Inorganic Compounds	560
21:6	Behavior of Inorganic Contaminants in Soils	563
21:7	Prevention and Elimination of Inorganic Chemical Contamination	567
21:8	Organic Wastes	568
21:9	Use of Organic Wastes for Crop Production	570
21:10	Soils as Organic Waste Disposal Sites	572
21:11	Soil Salinity	573
21:12	Radionuclides in Soils	575
21:13	Three Conclusions	576
22.	Soils and the World's Food Supply	578
22:1	Expansion of World Population	578
22:2	Factors Influencing World Food Supplies	579

22:3	The World's Land Resources	580
22:4	Potential of Broad Soil Groups	582
22:5	Problems and Opportunities in the Tropics	585
22:6	Requisites for the Future	590
Glossary of Soil Science Terms		593
Index		623

Chapter 1

THE SOIL IN PERSPECTIVE

MAN is dependent on soils—and to a certain extent good soils are dependent upon man and the use he makes of them. Soils are the natural bodies on which plants grow. Man enjoys and uses these plants because of their beauty and because of their ability to supply fiber and food for himself and his animals. Man's standard of living is often determined by the quality of soils and the kinds and quality of plants and animals grown on them.

But soils have more meaning for man than as a habitat for growing crops. They underlay the foundations of houses and factories and determine whether these foundations are adequate. They are used as beds for roads and highways and definitely influence the length of life of these structures. In rural areas soils are often used to absorb domestic wastes through septic sewage systems. They are being used more and more as recipients of other wastes from municipal, industrial, and animal sources. The deposition of undesirable silt in municipal reservoirs makes the protection of soils in upstream watersheds as important to the city dweller as to his counterpart on the farm or in the forest. Obviously, soils and their management are of broad societal concern.

Great civilizations have almost invariably had good soils as one of their chief natural resources. The ancient dynasties of the Nile were made possible by the food-producing capacity of the fertile soils of the valley and its associated irrigation systems. Likewise, the valley soils of the Tigris and Euphrates rivers in Mesopotamia and of the Indus, Yangtse, and Hwang-Ho rivers in India and China were habitats for flourishing civilizations. Subject to frequent replenishing of their fertility by natural flooding, these soils provided continued abundant food supplies. They made possible stable and organized communities and even cities, in contrast to the nomadic, shifting societies associated with upland soils and with their concomitant animal grazing. It was not until man discovered the value of manures and crop residues that he was able to make extensive use of upland soils for sustained crop culture.

Soil destruction or mismanagement was associated with the downfall of some of the same civilizations which good soils had helped to build. The cutting of timber in the watersheds of these rivers encouraged erosion and topsoil loss. In the Euphrates and Tigris valleys, the elaborate irrigation and drainage

systems were not maintained. This resulted in the accumulation of harmful salts, and the once productive soils became barren and useless. The proud cities which had occupied selected sites in the valleys disintegrated and the people migrated elsewhere.

History provides lessons which modern man has not always heeded. The wasteful use of soil resources in the United States during the white man's first century of intensive agricultural production provides such an example. Even today there are many who do not fully recognize the long-term significance of soils. This may be due in part to widespread ignorance as to what soils are, what they have meant to past generations, and what they mean to us and future generations.

1:1. WHAT IS SOIL?

CONCEPTS OF SOIL. Part of the lack of concern for soils may be attributed to different concepts and viewpoints concerning this important product of nature. For example, to a mining engineer the soil is the debris covering the rocks or minerals which he must quarry. It is a nuisance and must be removed. To the highway engineer the soil may be the material on which a roadbed is to be placed. If its properties are unsuitable, he must remove it and replace it with rock and gravel.

The average homeowner also has a concept of soil. It is good if the ground is mellow or loamy. The opposite viewpoint is associated with "hard clay" which resists being spaded up into a good seedbed for a flower garden. The homemaker can differentiate among variations in the soil, especially those relating to its stickiness or tendency to cling to shoe soles and eventually to carpets.

The farmer, along with the homeowner, looks upon the soil as a habitat for plants. He makes a living from the soil and is thereby forced to pay more attention to its characteristics. To him the soil is more than useful—it is indispensable.

A prime requisite for learning more about the soil is to have a common concept of what it is. This concept must encompass the viewpoints of the engineer, the homeowner, and the farmer. In developing this concept, brief consideration will be given to the practical and scientific discoveries of the past.

1:2. EVALUATION OF MODERN CONCEPTS OF SOIL

There are two basic sources of our current knowledge of soils. First, there is the practical knowledge gained by farmers through centuries of trial and error. This was the only information available before the advent of modern science, which now provides a second source of facts about soils and their management.