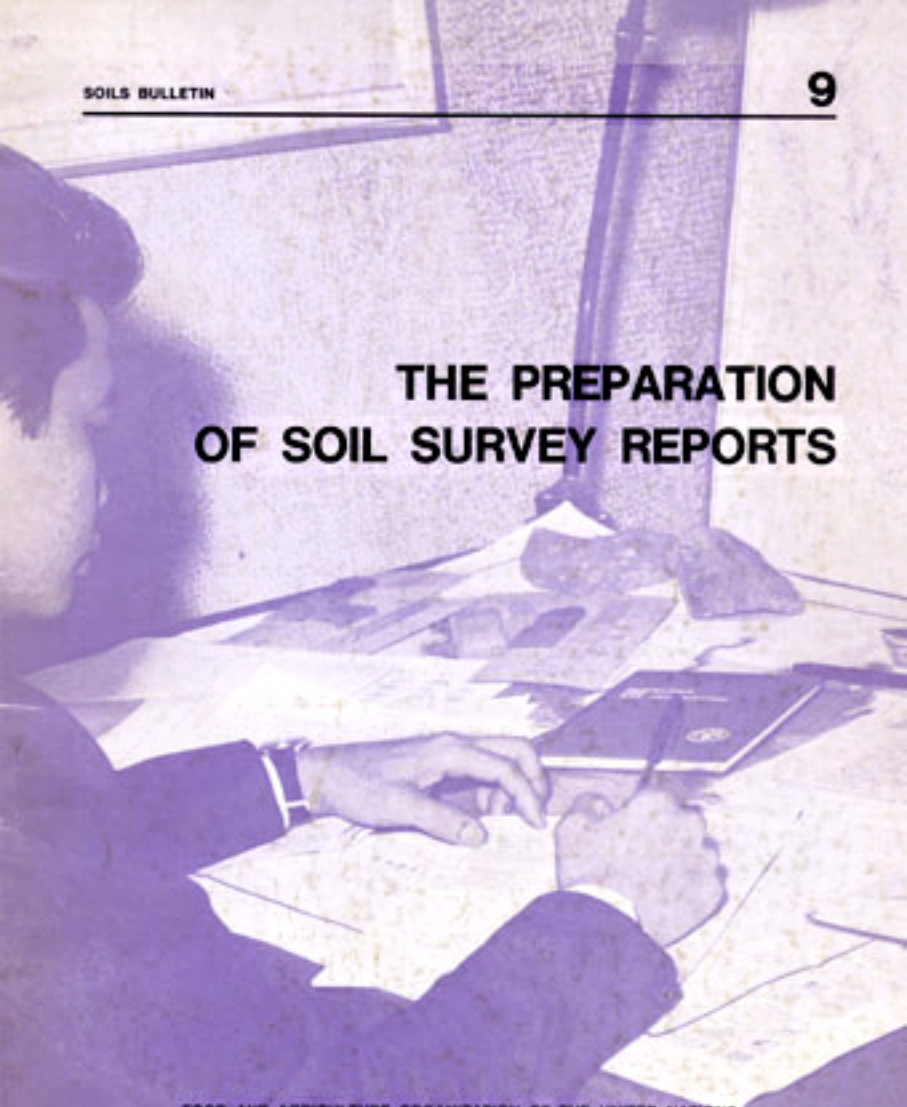
SOILS BULLETIN 9

THE PREPARATION OF SOIL SURVEY REPORTS



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

TABLE OF CONTENTS

INTRODUCTION

The purpose of this publication is to highlight some of the problems that arise in reporting the findings of soil surveys and to suggest ways in which these problems may be overcome. The publication is intended to serve as a general guide to report writing for soil surveyors employed by FAO, but it is hoped that it will prove valuable to a much wider range of readers. Therefore, while the proposals put forward conform to the general approach to technical reporting adopted by FAO, the publication does not include instructions on formal aspects of presentation which would be applicable only to FAO reports. For advice on such matters, FAO staff should refer to the Organization's reporting procedures for projects funded from a particular source. These are described in various FAO documents which are issued, and up-dated, periodically.

The amount of thought, effort, time and money which is employed in preparing and publishing soil survey reports is rarely commensurate with that lavished on the survey itself. In this sense, few enterprises pay so little attention to their final product. Admittedly, valuable information on soil qualities and distribution is often passed on by word of mouth, or interim report, whilst a soil survey is still in progress. Furthermore, some survey data is too voluminous to be reported and can only be stored in archives for future reference. Nevertheless, the lasting value of a soil survey, and the surveyor's reputation, largely depend upon the quality of text and maps in which the more important findings are described and interpreted. No surveyor can afford to assume that he will always be available to explain his work.

In a soil survey, as in any enterprise, the nature and requirements of the end-product must be considered from the outset and at every stage of work. The major questions which the report will be expected to answer must be clearly formulated at the start. Only then can the field work be planned and executed systematically to obtain the needed data. Early appreciation of report requirements provides a basis for the efficient collection and storage of data and ensures that no important gaps in knowledge are overlooked. Finally, the text and maps must be so arranged and presented that readers with differing interests can quickly find the information they are seeking.

The subject is discussed in relation to a proposed basic outline for soil survey reports which is summarized and explained in the first chapter. Information to be included under each heading of this outline is discussed in some detail in the second chapter. The third chapter describes how the basic outline may be adapted to meet the needs of individual surveys. This is followed by a chapter which considers the style of writing and of presentation best suited to soil survey reports. The fifth chapter, in recognition of the vital role of maps in soil survey reports, presents some important considerations in preparing soil maps and mapping legends for publication. Finally, an Appendix provides examples of both narrative and technical descriptions of soil units, prepared in accordance with recommendations given in the text.

ACKNOWLEDGEMENTS

This publication is based on a study of a large number of soil survey reports prepared by FAO and by other organizations. The author wishes to acknowledge the ideas and advice received from his FAO colleagues both in headquarters and in the field. Acknowledgement is also due to the Soil Conservation Service of the United States Department of Agriculture and, in particular, to Dr. Charles E. Kellogg, Deputy Administrator for Soil Survey, for permission to use ideas expressed in their draft guide for writers of soils handbooks and soil survey reports (1963), which was particularly helpful in the preparation of Chapter Four.

CHAPTER ONE

A BASIC OUTLINE FOR SOIL SURVEY REPORTS

In addition to providing a framework within which the problems of report writing can be conveniently discussed, a basic outline for soil survey reports serves a number of useful purposes:

(a) it expresses certain minimum requirements of all soil survey reports and ensures that these requirements are not overlooked when more detailed outlines for specific surveys are drawn up;

(b) it emphasizes the range of information to be obtained and carefully recorded during the course of a survey and is, therefore, a useful guide in the preparation of work plans when the survey commences. The minimum requirements of a soil survey report are, in effect, the minimum requirements of the survey itself;

(c) an outline of report requirements provides both incentive and guidance in studying available literature on the environment of a survey area and assists in making a preliminary selection of data which is likely to be significant in recording and interpreting the survey findings. In a similar way, it encourages the establishment of contacts with experts in fields other than soil science whose assistance will be required in the preparation of a reliable and satisfactory report;

(d) the optimum presentation of the results of an individual survey will probably necessitate some departure from the basic report outline but, so long as these changes are made within a standard framework, broad similarity in the arrangement of separate reports will remain. Uniformity of presentation offers obvious advantages to readers who may wish to compare the findings of different surveys and is especially helpful to editors called upon to combine reports on different surveys or reports on different aspects of a multi-disciplinary project.

The conditions under which soil surveys are undertaken are so diverse that it would be impossible to plan a report outline equally appropriate for all. This diversity arises not only through technical differences in the environment, or purposes, of the various surveys but also through administrative differences which dictate whether or not the final soil survey report will stand on its own or form part of a larger report involving other disciplines. Therefore, a fairly detailed report outline, specific to the survey itself, should be prepared as early as possible. Indeed, the requirements of this outline should be considered at the time that the work plans are drawn up, as soon as a general impression is obtained of the required complexity of the work and of the survey data. Experience from a number of FAO surveys, carried out under very diverse conditions, has already shown that the basic report outline presented in this text provides a suitable framework for the construction of detailed outlines for a wide variety of soil survey reports.

An enormous volume of data is collected during the course of most soil surveys. Even if it were possible, it would not be desirable to publish all of this data in the final report since data that was essential in explaining the main findings would be lost amongst data of very specialized interest. Nevertheless, all of the data should be carefully preserved. In soil surveys conducted by the Soil Conservation Service of the U.S. Department of Agriculture, all data collected as the work proceeds is placed in a "soils handbook" for the particular survey. The handbook is maintained in loose-leaf form so that data on

different subjects can be inserted in different parts of the book as and when it is collected. This is an excellent procedure. The soils handbook serves as a permanent record of all the data collected, from which information appropriate for the final report can be selected. Possession of a report outline at an early stage can be of obvious assistance in arranging the material in the handbook and in deciding where separate sheets of data should be inserted.

The headings of the basic outline for soil survey reports presently used by FAO are given at the end of this Chapter and the subject matter included under each of these headings is discussed in the remainder of the publication. Firstly, however, it may be helpful to explain the principles, or the reasoning, which underlies this choice of report arrangement.

BASIC PRINCIPLES GUIDING REPORT ARRANGEMENT AND CONTENT

Soil survey reports attract readers from many different walks of life and there are considerable differences in the length of time for which different aspects of soil survey information are likely to remain valid. These two important considerations are taken into account in planning the general structure of the report outline:

Subdivision of the Overall Report: Considerations of readership

In the basic outline the overall narrative part of the report is presented in three sections, each primarily directed at a different kind of reader;

(a) The Summary of Conclusions and Recommendations: This section is primarily intended for the busy administrator, often at a high level in Government, who may be vitally interested in learning how the broad findings of the survey can affect his development planning. He is unlikely to have either the time or the specialized interest to delve into details in the remainder of the report but if the summary encourages him to think it necessary, he is probably in a position to delegate a specialist to do this for him.

(b) The Main Body of the Text: This part is written for the general reader, who may have no specialized knowledge of soil science, but who has the time and the interest to find out as much as he can about the survey and is prepared, therefore, to read through the main body of the text consecutively. He expects the text to have a logical, consecutive arrangement and does not want his reading to be disrupted by lengthy inclusions of detailed data, or highly technical material which he does not need to understand. In developed countries, farmers themselves form an important part of the general readership of soil survey reports but in developing countries this readership is mainly composed of extension workers, junior administrators and professional men in soil science and other disciplines.

(c) The Appendices: In contrast to the main body of the text the various sections of the Appendix and their content are not intended to be read consecutively but rather to serve as a source of reference for the more complex, more technical findings of the soil survey. These sections are primarily intended for professional soil scientists who require such data for later studies in the area - and who may wish to check on specific technical points that are not of interest to the general reader.

Subdivision of the Main Text: The "life" and nature of the survey data

In the proposed outline the main body of the text is divided into four parts:

I. Description of the Environment

II. Survey Methods

III. Description of the Soils

IV. Interpretation of the Survey Data

The first three parts are factual. They are based on observations and measurements made during the survey and on factual data derived from other sources. The fourth part is different. It presents conclusions rather than facts. The conclusions themselves are based, of course, on the facts recorded in other parts of the report, but their validity is dependent on knowledge and on circumstances existing at the time of the survey.

Clear separation in the outline places desirable emphasis on the importance of the interpretative aspects of the survey findings. To many readers the interpretations will form the most interesting and valuable section of the report at the time it is published. It is important to encourage the author of a report to recognize this fact, so that he ensures that the interpretative section receives the attention it deserves.

Changes in social and economic conditions, and the acquisition of scientific knowledge, may eventually invalidate the interpretative part of the report without significantly reducing the value of the factual information. In other words, the interpretations are likely to have a much shorter useful "life" than the factual data. If need be, the latter can be reinterpreted at a later date. This consideration alone provides an excellent reason for keeping fact and inference in the report completely separate.

Subdivision of the basic outline in this way is convenient in explaining and emphasizing the lines of thought which should be followed in preparing detailed outlines for individual surveys. Whether or not it will be helpful to divide the actual report into separate parts, or whether precisely similar headings should be used, will vary from one survey to another.

Other important considerations which have guided the drafting of the basic outline include:

The Importance of Maps in Soil Survey Reports

Maps provide the most convenient source of information on soil survey findings and, to a large extent, the text of a survey report serves to answer queries which cannot be explained on the maps themselves. Recognizing the supporting role of the text and the need for easy cross-reference, the proposed report outline emphasizes that both factual and interpretative descriptions of the soils should be grouped in the text in the same units which are used on the various maps. Within the text it may well be desirable to refer to other groupings, but the headings and sub-headings used to group the descriptive material should correspond exactly to the mapping legends. Furthermore, all references to individual soils within the text should be clearly related to units shown on the maps.

Establishing Confidence in the Survey Findings

Emphasis is placed in the outline on description of the methods employed during the survey and of the criteria used in soil classification and interpretation. This information may later provide the only convenient basis for assessing the accuracy and validity of the survey and perhaps for deciding whether additional survey work in the area is necessary. It may be beneficial for a surveyor to consider at an early stage in his survey whether or not his methods will appear satisfactory under such exposure. The records required to give an accurate account of sampling intensity need to be collected from the very beginning of a survey.

The nature and presentation of explanatory material can also influence the credibility of a survey report. Novel conclusions or suggestions require explanation, particularly if they are, or appear to be, at variance with previous thinking. If the steps in this explanation can be supported by references to recognized scientific literature, so much the better. However, excessive explanation, particularly when supported by a mass of references that are scarcely relevant or carry little weight, can have the reverse of the desired effect, sowing seeds of doubt in a reader's mind where none existed before.

Allocating Space in Relation to Value

The various sections of a soil survey report are not equally valuable. Sections which describe the facts discovered and the interpretation of these facts are of fundamental importance. Other sections are mainly explanatory, describing how the survey was carried out, how the data was organized, and the environment in which the soils have developed and will be used. These supporting sections are by no means unimportant but a clear sense of proportion is needed to decide how much explanation should be included, how much the reader can be expected to find out for himself. By careful selection and reorientation of supporting information the author can save the reader much time and provide him with a better understanding of the survey findings. Each superfluous phrase makes the report a little less readable, a little less memorable. The space allotted to each theme needs to be weighed against the contribution it will make to the report as a whole. In particular, the author must guard against the intrusion of his own pet interests, lest they be allowed to occupy more than their share of the text.

The problems of apportioning available space need emphasis early in this publication for, in this connection, the expansion of the separate items of the basic outline given in later Chapters could be misleading. The amount of space devoted to describing the required subject matter under different headings reflects only the relative complexity of describing these requirements and bears no relationship to the relative importance of the different subjects or to the space which each should occupy in the report.

Proving that the Job Requested has been Completed

Many soil surveys are carried out in relation to specific terms of reference or as a part of a more extensive project with a specific plan of operations. It is most important to ensure that the report clearly indicates to what extent the original requirements of the survey have been fulfilled. This is not only a question of comprehensive reporting but also of logical layout. Failure to complete any part of the required work should be explained - not conveniently forgotten!

HEADINGS OF THE PROPOSED BASIC OUTLINE

Here, only the main headings of the different sections of the proposed basic outline are presented - in effect, a slightly expanded version of the table of contents of the proposed report. The suggested contents of each section is described in the next chapter.

INTRODUCTORY SECTIONS

Abstract

Acknowledgements

Table of Contents

(List of Tables and/or illustrations)

List of Maps

(Glossary of Special Terms - if brief)

Introduction

Summary of Conclusions and Recommendations

MAIN TEXT

Part I: The Environment

Chapter 1: General Description of the Area

(a) Location, population and communications

(b) Climate

(c) Physiography (including geology, geomorphology, relief and surface drainage)

(d) Natural vegetation

(e) Present land-use and human activity

(f) Other (factors of special significance in the area, e.g:- wild life; sources of water in arid and semi-arid areas, etc.)

Part II: Methods

Chapter 2: Survey Methods

(a) Office methods

(b) Field methods

(c) Laboratory methods

Part III: Soils

Chapter 3: General Properties of the Soils; their Genesis and Classification

(a) General properties of the soils

(b) The soil classification and mapping legend

(i) taxonomic soil classification and correlation
(ii) the mapping legend

Chapter 4: The Soil Mapping Units

Part IV: Interpretation of the Survey Data

(The number and titles of Chapters in this part of the report are dependent on the purpose and findings of the survey). A possible arrangement might be:-

Chapter 5: General Capability of the Area

(a) The land capability classification

(b) Land classification criteria

(c) The land capability groups

(d) Suitability of the soils for specific crops

Chapters 6 (7) (etc.): Suitability of (part of) the Area for Irrigation (rangeland) (woodland) etc.

(a) The suitability classification

(b) Classification criteria

(c) Interpretation of the classification

(d) Further studies required to implement development

CLOSING SECTIONS

References

(Illustrations)

(Glossary of special terms - if long)

Appendices:

(I. Additional Technical Information
- (i) survey methods
- (ii) soil genesis
- (iii) soil classification and correlation)

II. Detailed description of individual soil units

(III. Soil analytical data)

(Index or Indices, if any)

Maps

CHAPTER TWO

EXPANSION OF THE BASIC OUTLINE

This Chapter discusses in detail the subject matter which it is intended should be included under each of the headings of the Basic Outline.

INTRODUCTORY SECTIONS

Abstract

An abstract is provided at the very beginning of the report to enable a potential reader to judge very quickly whether he is likely to benefit from reading all, or part, of the report itself. Provision of an abstract also assists documentation services to include an adequate summary of the report in their records, through which the attention of many more potentially interested readers may be drawn to the report.

To serve these purposes the abstract must be short (about 250 words) and yet must provide a self-contained summary of the more important findings of the survey and of the methods by which these findings were achieved. All information summarized in the abstract must be available in the report.

Wherever possible it is desirable to provide translation of the abstract in widely used languages.

Acknowledgements

In FAO reports, acknowledgements of assistance received in the execution of the survey or in compiling the report are given on a separate page, immediately following the abstract. A section of acknowledgements can equally well be placed immediately after the Introduction.

The purpose of such a section is obvious but it needs to be prepared with care. The indiscriminate scattering of superlatives detracts from the apparent sincerity of acknowledgements and if all and sundry receive personal mention it is difficult to single out those most deserving of the author's thanks.

Table of Contents

A good table of contents illustrates the whole structure of a report and guides the reader to those parts of the text in which he has particular interest. The table must be comprehensive, including the headings of all important sections but if it is too detailed its value as a convenient source of reference will be greatly reduced. Some expansion of the table of contents is justified if the report includes no index.

Normally, it is desirable to include all "first-order" and "second-order" headings which appear within Chapters of the main text and possible "third-order" headings if their subject matter is of special reference interest. In addition, the table should clearly show the position of Conclusions and Recommendations; the Glossary (if any); the location of lists of maps, tables and illustrations and the subject matter of separate Appendices. If large separate maps accompany the report, their nature should also be listed.

Careful arrangement is important to the clarity of a table of contents. This includes insetting, to indicate the relative "order" of the various headings.[1] The wording of items

---

1/ The reader is referred to Chapter Three for a discussion of ways of indicating headings of different "order".

in the Table of Contents should correspond exactly with headings in the text. All page references must be correct, if the reader is not to be frustrated, indeed, infuriated. Checking of page references in the Table of Contents, and of cross-references in the text, is the last step in report preparation, immediately prior to printing.

List of Tables and/or Illustrations

Detailed lists, showing the subject matter and page reference of tables and/or illustrations, are of value to the reader for purposes of cross-reference. They are especially valuable when, for reasons of convenience and economy in publication, tables and illustrations are grouped in blocks within the text and are separated, therefore, from the subject matter which they illustrate.

List of Maps

This list also serves for cross-reference and refers primarily to small maps which are included within the text. Larger maps, appended to the report, may be included in the list, but such maps usually deserve separate reference in the Table of Contents.

Glossary of Special Terms

The aim of this section is to ensure that the text will be readily understood by the maximum number of readers. A very lengthy glossary should rarely be needed. A short glossary, confined to terms, weights and measures peculiar to the area surveyed and to a few technical terms, abbreviations or symbols, unavoidably used in the main body of the text, will usually be adequate.

The glossary should be placed at the front of the report only if it is so brief that the reader can reasonably be expected to remember the terms whilst reading the text. If the glossary forms a lengthy source of reference it should be placed at the back of the main text.

Introduction

The Introduction should provide a concise account of the purpose of the survey and of its organization and administration. It should include, without separate headings:-

(a) An outline of the purpose of the survey, summarizing the Terms of Reference (if any) and giving a brief account of the background which created the need for survey.

(b) A brief account of the execution of the project; starting and finishing dates; areas surveyed in various levels of detail; staff involved, national and expatriate (if any); training courses organized and of other activities or achievements not directly related to the immediate aims of the survey.

A final paragraph can usefully be devoted to explaining the arrangement of the report, drawing attention to the Summary of Conclusions and Recommendations and explaining the separation of factual and interpretative data and the presence of more technical information in the Appendices.

The basic outline does not include a Preface. On occasion, however, a Preface signed, if not written, by a person of high standing, can add authority to a soil survey report. It should be very brief and should draw attention to the contribution made by the survey to development aims. Normally, a Preface precedes even the Table of Contents, appearing immediately after the title page.

Summary of Conclusions and Recommendations

A soil survey should lead to the formulation of a number of precise conclusions relating to the nature and distribution of the soils studied and to their development potential. A need to recommend certain specific lines of future action may also be recognized. These findings will be discussed in detail in various parts of the text. The complexity of soil survey findings is such that they can very rarely be summarized adequately in the report Abstract. Yet a summary of findings is very desirable for the benefit of busy administrators and planners who may have only marginal interest in the more technical aspects of the report.

Logically, a summary of conclusions and recommendations should appear at the end of the narrative part of the text. In a short report this placing would be satisfactory. Placement at the beginning is recommended, however, to ensure that this summary is not lost amidst text and appendices, which in most soil survey report are unavoidably lengthy. Coming at the beginning, it is especially important that the subject matter of this section be confined to a summary of the findings of the survey, lest it include very obvious and very tedious repetition of the Abstract or of the Introduction.

Many readers will judge the value of the survey from the contents of this section. Clearly, therefore, it is the most important section of the report and must be prepared with exceptional care. It must be concise, but it must also be self-explanatory. Its purpose is to encourage readers to study the remainder of the report but they should not be forced to do so in order to obtain a general understanding of this section. To assist readers to locate information of particular interest, individual conclusions and recommendations should be cross-referenced to related discussion in the main text.

Any temptation to impress the reader by the sheer volume of conclusions and recommendations arising from a survey must be firmly repressed. Inconsequential comments serve only to distract attention from recommendations and conclusions of real import. Thus, the contents of this section can only be finalized when the remainder of the report has been completed and the relative importance of all items considered for inclusion can be validly assessed.

A clear distinction should be drawn between conclusions, which call for no immediate action and for which some element of uncertainty is permissable, and recommendations, which must be firmly stated and unambiguous. Separate sub-sections, possibly with separate sub-heads, should be devoted to conclusions and to recommendations.

In summarizing the findings of the survey in the sub-section on conclusions, emphasis should be placed on interpretative findings, since these are likely to interest a wider range of readers. The sub-section can usefully open with a statement, frequently in tabular form, of the proportion and/or areas of soils (or land) of differing potential identified. Purely numerical distinctions between soil (or land) classes, e.g:- Class I, Class III, are not sufficient. The significance of each class must be briefly defined, although it may be desirable to note that more precise definitions of each class appear later in the text. Where possible, practical alternative uses of all, or part, of the surveyed area should be summarized. The general nature of development requirements (e.g:- inputs, such as fertilizers, mechanization, drainage, etc.) should be outlined and any major social, technical or economic development problems should also be summarized.

Areas mentioned in the conclusions, or the recommendations, should be identified in such a way that the reader can locate them on one or more of the maps which accompany the survey report.

If they are to stand a good chance of implementation, recommendations should be pertinent, practical and not too numerous. Subjects which, in different surveys, may usefully form the basis of recommendations include:-

(a) the identification of areas where immediate development effort is recommended;

(b) the identification of other areas having future development possibilities;

(c) the nature of additional survey work required prior to development, in particular to provide "feasibility-grade" data to attract investment capital;

(d) the need for research, or pilot development, to solve specific problems;

(e) the need for organizational or administrative changes to facilitate development. (Such recommendations must remain within the competence of the soil survey team and the action required should be within the capacity of the authority responsible. A recommendation for an increase in laboratory support by the establishment of a field laboratory is a possible example).

(f) specific proposals for the establishment of training courses and/or training facilities for survey staff,

Each recommendation deserves a separate paragraph. If, unavoidably, there are a very large number of recommendations, it may be desirable to group them according to subject matter under minor headings. To emphasize the important purpose of these paragraphs they should be introduced individually, or collectively (depending on their number) by the phrase "It is recommended that..."

If the survey report is but a contribution to an overall report on a multi-disciplinary project, the surveyor must ensure that his conclusions and recommendations are not at variance with those of his specialized colleagues. If need arises, he must negotiate compromise recommendations before writing this section.

MAIN TEXT

Part I: The Environment

Chapter 1: General Description of the Area

This part of the report should give a concise, yet reasonably complete and accurate, picture of the environment of the survey. As a minimum requirement, each section should provide all the information needed to support the conclusions and interpretations made in the remainder of the report.

In most reports the chapter should include a small scale map showing the location of the survey(s) in relation to the country as a whole. Other small maps showing the distribution of vegetation, climatic phenomena, etc. within the area(s) surveyed can be very helpful in reducing the required amount of text.

In preparing this chapter the author should draw upon all available information relating to the area, clearly indicating the source of his data in each case. In many areas a large amount of such information will be available. The author must then make a careful selection, avoiding data that is not strictly relevant to the description or interpretation of the soils which he has surveyed, and carefully summarizing the remainder.

The sub-headings proposed for this Chapter in the Basic Outline are only intended as a guide. They will meet the needs of many surveys but the adequate description of certain environments may demand slight changes in emphasis and the inclusion of additional headings. For example, in describing many arid or subarid areas, separate sub-sections on geomorphology and hydrology are desirable.

Part II: Methods

Chapter 2: Survey Methods

This Chapter should provide a concise, purely factual statement of the methods employed in the survey. It should reveal the true intensity of the survey and, by demonstrating that the methods used justify both the detail of soil mapping and the interpretative conclusions, it should establish confidence in the survey findings. Choice of scale for published soil maps is largely a matter of convenience. Valid judgement of survey intensity can only be based, therefore, on knowledge of the nature and density of observations.

The Chapter is likely to be more easily understood if it opens with a short paragraph summarizing the general approach employed. For example, a rapid reconnaissance to establish a working legend may have preceded systematic survey work; problems of classification may have been studied in greater detail in representative sample areas; and systematic work may have proceeded simultaneously from different centres. An introductory paragraph outlining the operational sequence of preparatory office work, field work, photo interpretation and final field checking, is particularly desirable when extensive use has been made of air photo interpretation. It will always be of general interest to record the amount of time spent on each phase of the work in relation to the area being covered.

The methods used in the office, in the field and in the laboratory should then be described in required detail under separate sub-heads.

The description of office methods should include information on the scale and quality of available air photos, mosaics, topographic base maps and other maps (geology, vegetation, etc.). Any special techniques of air photo interpretation which were used should be described, together with information on cartographic methods, especially those relating to the transfer and reduction of field sheet data.

In describing field methods special attention should be paid to the kinds of observation made. Pits of various sizes, auger borings, studies in road-cuts etc. should be distinguished and the average depth of sampling and intensity of sampling by each method described. The kinds, and bore diameter, of each kind of auger used should be recorded. If the intensity of ground observations varied widely over the survey area this should be indicated by an appropriate map or "reliability" diagram. It is often desirable to include such a diagram on each of the main survey maps. The sites of profiles described in detail in the text and of pits from which analysis data was obtained should also be shown on an appropriate map.

Particularly in relation to field work, a bald statement that the methods employed were those of the U.S. Soil Conservation Service, or of some other well-known body, is not sufficient. Some readers may be unfamiliar with these methods, others may question whether the standards required by such bodies were fully maintained unless the methods employed are adequately described. This does not forbid, of course, reference to standard texts (e.g:- the FAO "Guidelines for Soil Description" or the "Soil Survey Manual" of the U.S. Department of Agriculture, in place of lengthy description of specific aspects of method, such as terminology in profile description.

Full description of laboratory methods is usually unnecessary, unless new techniques or modifications to existing procedures were specially developed to overcome analytical problems encountered during the survey. The information given must be sufficiently detailed and sufficiently well-referenced, however, as to ensure that all the techniques used are accurately identified.

It may not be practical to provide concise explanations understandable to the lay reader for all aspects of "method" and some data relevant to this chapter may be lacking in general interest. All highly technical or purely reference information should be transferred to an appendix. Indeed, in planning an individual report, consideration should be given to the desirability of transferring all technical data on methods to the appendix (see discussion under "Appendix").

Part III: Soils

Chapter 3: General Properties of the Soils; their Genesis and Classification

This chapter serves as an introduction to the soils of the area by describing their most significant properties and by explaining the principles on which criteria have been selected to distinguish the individual soil mapping units.

(a) General properties of the soil

This first section deals with:

(i) general information on the morphological, physical and chemical properties of the soils;

(ii) the relationships between differing soil properties and differences in geology, topography and other soil forming factors of importance in the area surveyed;

(iii) the significance of these different properties in relation to the general potential of the soils for agriculture.

If the number of soil units mapped is large and their pattern complex, it may be convenient to describe the general properties of the soils by reference to a simplified map at a small scale. This is usually the case in reports dealing with semi-detailed surveys or with detailed surveys of substantial areas. The small scale "general soil map" should show "broad associations" of the units on the soil maps proper. If these groupings are carefully chosen, the "broad associations" should provide an adequate basis for describing the most significant soil differences. The relationships between geology, topography and the various "broad associations" of soils can often be illustrated very conveniently in one, or more, block diagrams.

In this section, comment on the general potential of the soils should be related to the geographical areas covered by the "broad associations" (the potential of individual soil units will be discussed in Part IV). The comments should reflect only the least controversial aspects of interpretation, such as limitations due to poor drainage, shallowness, steepness, surface stoniness, etc.

Discussion on soil genesis has a place in this chapter only insofar as it will assist the reader to understand the range and distribution of soil characteristics to be found in the area surveyed. As far as possible, such discussion should be self-explanatory and written in non-technical terms. The author should avoid any temptation to write an elementary text book on soil genesis. Even more strictly should he avoid an abstruse scientific dissertation on the subject. If interesting scientific discoveries or observations requiring highly technical description have been made, these might provide suitable material for an extra appendix to the report (assuming that they cannot be published conveniently, and more appropriately, elsewhere).

(b) The soil classification and mapping legend

In most soil surveys, soils are classified into taxonomic soil units and these are grouped, to a greater or lesser extent depending on the intensity of survey, to form units

shown on the soil map and described in the mapping legend. Therefore, this section of the report is divided in two parts. The first part describes the principles of taxonomic classification employed, lists the taxonomic units identified and shows their correlation in relation to internationally recognized systems of soil classification. The second part presents the soil mapping legend and explains the principles employed in grouping taxonomic units to form mapping units.

(i) taxonomic soil classification and correlation

In this part of the report only the general principles of the taxonomic classification employed need to be described, since details of the characteristics which distinguish individual taxonomic units will be given in the next chapter as a part of the description of the mapping units in which they occur.

In distinguishing units at a low level of taxonomic classification (e.g: the soil series) arbitrary decisions have to be taken on such matters as the relative importance of different morphological features; on the choice of control horizons for drawing textural or colour distinctions; on the morphological criteria used to distinguish different drainage conditions; and on other similar considerations. If such decisions have been applied consistently throughout the classification, repetition in Chapter 4 can be avoided by explaining the principles adopted once only in this part of Chapter 3.

In detailed surveys, classification at levels higher than the soil series may not be essential to the immediate interpretation of survey data for practical purposes. Nevertheless, by showing their grouping at higher levels of classification, existing relationships between the soils identified can be demonstrated and the possibility of improving interpretations by correlation with like soils elsewhere can be created. Indeed, if no high level classification is attempted the value of the survey findings is unnecessarily limited to mere local interest. For purposes of international soil correlation, grouping at the Great Soil Group level is necessary and to facilitate interpretative correlation more detailed grouping at the 'family' level is desirable.

No globally-accepted system of soil classification is yet available but most countries have adopted one or other internationally recognized system for use in all soil survey work. When reporting on the use of such system a reference to the published description of the system will usually make it unnecessary to provide any further explanation of nomenclature, principles or criteria used at levels of classification higher than the soil family. If, however, the system has been adapted in any way to meet local requirements, the changes introduced must be described (wherever possible such changes should be avoided).

In addition, to facilitate correlation, it is desirable to indicate the classification of the soils identified in terms of other internationally recognized classifications with which the author is familiar.[1] This can usually be done in the form of a table with little, if any, explanatory text. All taxonomic units recognized should be listed in such a table and compared horizontally with comparable units in other classification systems. Some explanation will be required if there is significant overlap between units in different systems.

In many surveys it is both possible and desirable to include a further table in this part of the report which summarizes the most important diagnostic and descriptive characteristics of each taxonomic unit recognized and indicates the extent of the unit within the survey area.

1/ FAO soil surveyors are normally expected to correlate classifications in the system currently in use in the country of survey both with the units of the legend of the World Soil Map and with the latest version of the new soil classification system of the U.S. Department of Agriculture.

(ii) the mapping legend

This subsection should include the complete legend shown on the soil map, for the reader may not always find it convenient to refer to the map for this information. Very often the opportunity can be taken to supply more detail in a legend included in the text than is possible, for reasons of space, on the maps.

In some surveys, the legend, together with the information on taxonomic classification given in the previous subsection, will provide an adequate explanation of the method of distinguishing mapping units.

In other surveys, notably those at semi-detailed intensity in which extensive use has been made of air photo interpretation, the boundaries between mapping units may be related with more certainty to changes in physiography than to changes in soil morphology. For the benefit of other soil scientists who may wish to supplement or further interpret the survey data, it is essential when reporting on this type of survey to give a full explanation of the physiographic criteria used in mapping the separate units; taking note that special care needs to be given to describing and defining physiographic units if the distinctive, as opposed to merely descriptive, criteria are to be adequately identified in a few words. Even in these surveys, it is desirable that individual mapping units be named and described in terms of the soil units which they enclose, although they may well be grouped in terms of physiographic criteria (see further discussion of map legends in Chapter 5).

Chapter 4: The Soil Mapping Units

The data in this Chapter represents the foundation on which the remainder of the report is constructed. The survey maps show the distribution of the different kinds of soil recognized and the interpretative sections of the report record present conclusions on their relative potential. These are not very meaningful, however, if the distinguishing characteristics of the soils are not adequately described. Furthermore, as conditions change, further interpretation is likely to be required and this can only be undertaken if the characteristics of each kind of soil can be thoroughly understood from the report.

In presenting a description of the separate soils identified, the author is faced with two difficult problems:-

(a) How much detail should be included in the main text, bearing in mind that this part of the report is intended to be read consecutively?

(b) How should the descriptions be arranged?

Detailed description and corresponding analytical data of all soils of significant extent in the area must appear somewhere in the report for reference purposes. This demands description of all important characteristics of each separate horizon of modal, or representative, soil profiles. The inclusion of such descriptions within the main body of the report, however, disrupts the text, making the report more difficult to read and may deter readers who are not soil specialists.[1/] As a general rule, therefore, it is recommended that the detailed descriptions of individual soils be placed in a reference appendix and that short narrative descriptions of each soil should appear in the main text for the benefit of the general reader.

1/ A very satisfactory solution to this problem is possible when publication methods permit the use of type of markedly different size (i.e:- in printed reports, or by using photographic reduction). In this case, detailed technical descriptions, together with analytical data, occupying a single page of very small type, can be inserted in the main text preferably on facing pages to the corresponding narrative descriptions. The difference in type size avoids disruption of the main text.

In some surveys, it may be convenient to distinguish a small number of soils which, because of their extent, agricultural significance or scientific interest, are of special importance. It may then be desirable to include detailed descriptions of these "benchmark" soils within the main text. Whether or not to do so is a delicate decision and, in making it, the author should ensure that he is not being misled by his own specialized interest.

The narrative descriptions of each soil unit, which it is proposed should comprise this part of the text, should be concise and as brief as possible. Yet, they must provide sufficient information on the morphological changes with depth as to characterize each of the soils included in each mapping unit. For each soil the characteristics of colour, texture and structure should be broadly described together with information on other characteristics which are significant in their generalized profile. Diagnostic characteristics which serve to distinguish the soils of one mapping unit from another, or to distinguish soils included within the same mapping unit, should be emphasized.

In addition, the narrative descriptions should include a brief statement on the environmental situation of each mapping unit (geology, topographical position, vegetation, special aspects of present land-use, etc.) again emphasizing factors which are peculiar to, or characteristic of, the unit in question.

The problem of arranging and grouping the separate soil descriptions is solved, in part, by the proposed title of this Chapter - The Soil Mapping Units. This emphasizes that the Chapter presents an expansion of the information provided by the soil map and implies that the relationship between the units mapped and the units described must be immediately apparent. Therefore, if the mapping units are grouped under headings and sub-headings in the legend of the soil maps, the same grouping and headings should be employed in the text. There should be an introductory paragraph, or paragraphs, to each group of descriptions explaining the characteristics which are common to the units included within the group. These common characteristics may be physiographic, taxonomic, genetic or geological, depending on the basis of grouping employed in the soil map legend.

In some soil survey reports, the authors have chosen to use different groupings of soils for mapping and descriptive purposes. For example, soils may be grouped in relation to natural physiographic features in the mapping legend but, in the text, they are grouped in relation to a taxonomic classification. On occasion, this appraoch may avoid repetition and even increase the clarity of the text itself but it is not recommended, since it complicates comparison of text and map and may create difficulty in identifying the distribution of the described soils. Needless to say, the requirements of the descriptive text should be carefully considered when the final legend of the soil map is drawn up (see Chapter Four).

Frequently, soil mapping units embrace more than one kind of soil. A general description of such units, including, if possible, an estimate of the relative proportion of the unit occupied by each kind of soil, should be followed by separate descriptions of the characteristics of each included soil. If the same soils occur in more than one mapping unit, a suitable cross-reference can obviate the need for repeating soil descriptions.

An illustration of the application of these principles in preparing simple narrative soil descriptions and of the kind of information which can usefully be included, is given in Example 1 in the Appendix of this publication.

Part IV: Interpretation of Survey Data

This part of the report explains the immediate practical significance of soil differences recognized and mapped during the survey in relation to the various development possibilities which the environment offers. The exact nature and the best arrangement of this information will depend on the particular circumstances of the area surveyed.

The number of chapters, for example, will usually be related to the number of separate lines of development which appear practical and for which separate interpretation of the soil data is necessary. The contents of each chapter and, in particular, the nature of the explanations provided should be adapted to the background knowledge which those who will make most use of the Chapter are expected to possess. Therefore, in the basic outline it is not possible to give more than a general indication of the chapter headings likely to be required. Furthermore, the elaboration of this outline can only be discussed in terms of general principles.

Chapter Subjects

The first chapter in this part of the report should usually be devoted to a general assessment of development possibilities, indicating which areas show greatest development promise. Exceptions to this rule are reports on areas where the range of development possibilities is extremely limited, such as arid areas in which only an irrigability classification would be meaningful.

The interpretations should cater for as many as possible of the lines of development which appear practical in the area surveyed. It is the responsibility of the soil surveyor to interpret the potential of the soils in their environment in relation to all important crops to which they are suited and under various alternative forms of management or usage, rather than to recommend the form of land use which should be adopted. The latter decision is dependent on many factors other than soils. Separate chapters are usually needed for each major field of possible development (e.g:- irrigated agriculture, forestry, rangeland development, engineering uses, etc.).

Whether or not interpretation in relation to a particular form of management or land use is deserving of discussion in a separate chapter depends upon the probable future importance of this form of management; on the extent to which it is specific in its soil requirements; and, in practice, on the amount of pertinent data available. An exploratory survey, for instance, may not yield sufficiently detailed data to justify more than a single interpretative chapter describing General Land Capability.

Occasionally a single crop may occupy so important a place in the agricultural economy that estimates of soil suitability and of management requirements for this crop alone deserve a separate chapter. Similarly, groups of crops having similar requirements or involving similar management practices, may conveniently form the subject of separate chapters (e.g:- tree crops, arable crops, rangeland, woodland, etc.).

Assessment of the suitability of soils for irrigation should form a separate chapter whenever a substantial part of the survey area has irrigation possibilities and the necessary specialized investigations have been carried out in sufficient detail to make reasonably reliable assessment possible.

Interpretation of the engineering properties of soils may be of great significance in the planning of development, especially in relation to road construction. In most countries, government engineering departments can assist the soil surveyor to develop broad assessments of the engineering uses of his more extensive soils. Such information will only be available if the needs of a good report have been foreseen well in advance of the end of the survey. If the volume of data gathered does not justify a separate chapter, information on engineering properties can be included as a subsection in the general assessment of the area.

In addition, it may be desirable to include one, or more, chapters explaining how the soil survey data and its interpretations can be used in development planning at different levels, or in implementing specific aspects of development. These chapters should include specific advice on the nature of further survey and experimental work required before investment can be attracted and development initiated.

The Content of Interpretative Chapters

In the basic outline it is suggested that each chapter dealing with a different aspect of possible development should have four main sub-divisions:

(a) The capability (suitability) classification

(b) Classification criteria

(c) Interpretation of the classification

(d) Further studies required to implement development

This suggestion recognizes that a separate capability classification will usually be desirable to group the basic soil mapping units in relation to their relative potential for each development purpose. Under the first subhead definitions of each class or unit in this classification are provided. While such definitions usually include some information on the environmental character of areas included in the class it is rarely practical to define all the characteristics used in distinguishing the classes. The specific diagnostic criteria for each class are listed, and if need be explained, therefore, udner the second proposed subhead. Thirdly, the significance of the resulting grouping of mapping units is analyzed to give both overall and localized assessments of the potential of the surveyed area for the particular development purpose. The final subsection describes the nature of any further studies required before development can be implemented.

The actual headings of these subdivisions need to be adapted, of course, to the subject matter of the interpretative chapter. For a discussion of rangeland possibilities suitable subheads might be:-

(a) The Rangeland Capability Classification

(b) Rangeland Classification Criteria

(c) The Potential for Rangeland Development

(d) Further studies Required Prior to Rangeland Development

The requirements of each of these proposed subdivisions will now be discussed in more detail.

(a) The capability (suitability) classification

Wherever a system of quality classification is employed each unit of the classification identified in the survey area 1/ must be precisely defined. This is true even if the system used is based on the Land Capability Classification of the U.S. Bureau of Reclamation, or any other well-known system. It cannot be assumed that the reader will have easy access to exact definitions used in these classifications - and the exact definitions are important. Furthermore, a well-known system may require to be adapted in order to explain the potential of a particular area most conveniently, most effectively, and within the framework of available data. It is essential that these adaptations are clearly explained.

In relation to the definition of classes in a capability classification the following points deserve emphasis:

1/ If the classification used is well-known within the country, it is permissible to define only those classes which appear within the survey area but, for the sake of clarity, it should be explained that no land corresponding to the missing classes was identified.

(i) The classification should be exhaustive and its various subdivisions should be mutually exclusive.

In other words, the range of the classification should embrace all the kinds of land or soil in the area under consideration and there should be no overlap or ambiguity in the definitions of separate classes. Overlap is difficult to avoid in defining land or soil classes, since very many independent variables are involved. For each classification, therefore, a specific theme, governed by a limited range of variables, should be chosen to serve as a basis for distinguishing and comparing subdivisions throughout the classification. Definitions of individual classes may include additional information but the crux of each definition will be the defined position of the class in relation to the unifying theme of the classification. For example, in the system of land classification described in the Manual of the U.S. Bureau of Reclamation (1953) the concept of relative payment capacity provides a basis for comparing the potential of all the classes recognized, although individual classes are also defined in terms of other characteristics. In the land capability classification of the U.S. Department of Agriculture (Klingebiel and Montgomery 1961) soil limitations of increasing severity, which determine the range of agricultural uses of the land and the nature of management required, provide a central theme which is applied throughout the classification. If, in the absence of a unifying theme, differing criteria are used to define separate classes, problems of overlap in class definitions are very likely to arise, especially if it is necessary later to extend the classification to adjacent survey areas.

(ii) The parameters of the classification should be clearly explained.

In the first place, it is necessary to establish very clearly whether the classification relates to units of "soil" or of "land". As a matter of course, systematic soil surveys record phases of slope, topography, incidence of erosion, surface stoniness and other factors which many would consider to be characteristics of land rather than of soil. In fact, the areas enclosed by soil boundaries on a soil map represent actual areas of land possessing a variety of environmental characteristics of which soil characteristics are but one aspect. Therefore, capability classifications which relate to mapped units should almost invariably be developed as land classifications. On the other hand interpretative classifications which describe the capability of taxonomic units of soil,1/ on the basis of the defined characteristics of these units wherever they may be found, are specifically soil classifications. The point to be emphasized is that "land" is a broader concept than "soil". The two words are not interchangeable but must be carefully selected in drafting titles, definitions and explanatory text for systems of capability classification.

Secondly, the choice of parameters and the way in which they are used in defining classes of either land or soil require to be explained, since these may differ from one interpretative classification to another. What physical aspects of the environment have been taken into account and more significant, since this is more difficult for the reader to assess, to what extent have economic and social factors been taken into consideration? It is important, for example, to indicate whether climate, or the availability of water for drinking or irrigation purposes, has been considered in assessing possibilities of land-use. Have levelling, terracing, or other management requirements been considered in qualitative or quantitative terms? Economic considerations arise directly, or indirectly in almost any interpretative classification. Have these been investigated by an economist or have they been assessed on a purely relative and arbitrary basis?

1/ Units of soil defined in terms of a specific arrangement of soil characteristics within a defined environmental situation.

Lastly, particular levels of present or future management are implicit in almost all assessments of land capability or potential. These management assumptions should be described as precisely as possible. This is specially important when the classification relates, in fact, to changed environmental conditions which will exist only after a system of management new to the area has been introduced. Irrigation, in particular, is likely to induce very significant changes in soils and land and in interpretative classifications of semi-arid areas it is essential to indicate whether rainfed or irrigated agriculture is assumed. Separate classifications for rainfed and irrigated conditions will usually be desirable in such areas.

(iii) The definition of each interpretative class must be as precise as possible. In particular, the significance of subjective terminology ("good", "moderate", "marginal", etc.) must be explained.

(iv) Any exceptions to the general definitions (e.g:- in relation to particular crops) should be indicated.

These considerations imply that a good report requires more than a simple listing of the definitions of each interpretative class. Several introductory paragraphs will usually be required to explain the general form and the setting of an interpretative classification. On rare occasions further paragraphs following the list of defined classes, are desirable to explain points arising in individual class definitions. These explanations do not require to be very lengthy.

(b) Capability classification criteria

The definitions of individual classes, which would be presented under the previous subhead, are primarily concerned with the potential of the class for a given purpose. Within reasonably concise definitions it is usually impossible to include sufficient detail of the diagnostic environmental criteria of each class to permit the reader to fully appreciate the basis of the classification, much less apply it himself. Therefore, wherever possible, the diagnostic specifications (range of texture, slope, salinity, etc.) of each class should also be provided in the report. This information can usually be presented in tabular form with a minimum of additional explanation.

(c) Interpretation of the capability classification

Mere classification of the separate areas into different quality classes rarely provides the best interpretation possible with available data. Different limitations may decide the classification of various parts of the area within a single class and the surveyor may be aware of other differences between mapped areas which the classification does not adequately reflect but which would call for variations in management. These variations can be usefully described.

Firstly, however, this subsection should present an overall assessment of the potential of the area for the particular purpose. Localities best suited should be indicated and their area reported. Identification of areas is simple if maps illustrating each aspect of interpretation are available but in the absence of such maps any reference to particular soils, or particular areas, must be very carefully related to mapping units shown on the basic soil maps.

Here the opportunity can be taken to include all available information on anticipated yields from areas of different capability class together, if possible, with economic data on the expected costs and benefits of recommended practices. Such data is of great value in helping the reader to appreciate the practical significance of the classification. They cannot be included in the definitions themselves since changing circumstances may shortly make the exact figures unreliable, although they may continue to provide guidance on the order of magnitude of differences between classes.

Insofar as they differ, the management and conservation requirements of each interpretative unit require to be described. This will usually necessitate breakdown of the subsection into groups of paragraphs each with a heading corresponding exactly with the titles of the mapping units on the appropriate interpretative map.

(d) Further studies required to implement development

All the information needed to implement development possibilities will rarely be available on completion of a soil survey, particularly if the survey is at a small scale. To actually plan development at the farm level and to provide the precise information needed to attract investment, more detailed surveys and other soil studies are likely to be required in various parts of the survey area. This section of the report offers the author opportunity to draw on his knowledge of the problems and complexity of the soil pattern in making recommendations on the scale and intensity of further surveys that would be required to meet such aims. He should also draw attention to any need for experimental work, possibly in soil fertility, drainage, reclamation or conservation, required to consolidate and refine his interpretations.

CLOSING SECTIONS

References (or Bibliography)

Scientific ethics and courtesy demand that all material drawn from the work of other authors be acknowledged by providing a list of these authors and their works suitably cross-referenced to their contribution(s) in the text. The method which is most convenient, and least subject to error, is to list the authors alphabetically together with full details of their pertinent publications, arranged according to their year of publication, and to include the author's name and year of publication as a cross-reference in the appropriate part of the text. The standard arrangement used for bibliographic reference in FAO publications is as follows:-

Blimp J. 1917	Textural variation in sandbags. Journal of War Science: Vol. 13 No. 2

The corresponding cross-reference in the text would be:-

"....(Blimp, 1917)" or "Blimp (1917) declares...."

Illustrations

Practical considerations of publication often make it necessary to group photographic illustrations, often at the end of the main body of the text. This restriction rarely applies to line diagrams or graphs, which may be placed in any part of the text. In his draft report the author should indicate to the publisher the way in which photographs should be grouped (particularly if pairs of pictures are required to appear on facing pages) and the positioning of line diagrams. He should also provide suitable captions and acknowledgements where necessary. At the editing stage it is important to check that numbered illustrations are correctly cross-referenced in the text.

Glossary

This should be included in the closing section of the report if it is lengthy (see Introductory Sections).

Appendices

All information which is too technical to be appreciated by readers who are not professional soil scientists is best placed in appendices to the main text. The appendices are intended primarily for reference purposes but they may also include technical explanations of methods, procedures and problems of interest only to the specialized reader. Since they must include detailed technical descriptions and laboratory data for all the more important soils identified, it is not unusual for the length of the appendices to considerably exceed that of the main text.

If the appendices are long, their reference purpose is best served by careful subdivision of the information under concise headings and subheadings and by providing an additional table of contents at the beginning of the appendix section.

In the basic outline a possible need for three appendices is recognized.

Appendix I. Additional Technical Information

This section is intended to include discussion of survey methods, problems of genesis, and general problems of classification and correlation which are too technical to be appropriate for the main text but which are essential to the full understanding of the report by the soil specialist. It merely supplements corresponding discussions in the main text and should be subdivided under corresponding headings. Repetition between main text and appendix should be carefully avoided. Problems of genesis, classification and correlation which relate to individual soils can be more conveniently combined with the technical description of each soil in the next section of the appendix.

In many, if not most, soil survey reports, this first appendix will be unnecessary. The need is greatest when the majority of readers of the main text are expected to have only a very modest technical background. In this situation it may be desirable to substitute the chapter on "Survey Methods" in the main text with one on "How the Survey was Made", describing briefly and in the simplest terms the basic principles of soil survey (the location and nature of observations; the recognition of diagnostic horizons and the grouping of like soils). Technical information on survey methods (sampling intensity, photo interpretation techniques etc.) would then require to be placed in the appendix.

Appendix II. Detailed Description of Individual Soil Units

This appendix is essential in almost all soil survey reports. It provides morphological descriptions in full technical detail of every soil which is reasonably extensive in the survey area. The possibility of extending the survey to adjacent areas and of correlating the soils identified with soils elsewhere may depend on the quality of these descriptions. Suitable methods of soil descriptions are given in "Guidelines for Soil Description" published by FAO in English, French and Spanish.

The descriptions required in a soil survey report will usually relate to whole units of soil, rather than to individual soil profiles. Therefore, whilst the description should include details of a single representative profile, it must also include reference to the range of morphological and environmental characteristics permitted to occur within the soil unit as a whole. Attention should be drawn to any characteristics of the described profile which diverge from the central concept of the unit. Only if the range of characteristics permitted within the unit is exceptionally broad should it be necessary to include descriptions of more than one representative profile. In most surveys detailed descriptions of a number of profiles representing the more extensive soil units will be available. From amongst these, one profile which best represents the concept of the unit should be carefully selected for inclusion in the report. The remainder should be carefully preserved with other survey records to assist in later correlation and interpretative work in the area.

Bearing in mind that these descriptions are intended to assist specialist readers to recognize the soils described and to appreciate their particular characteristics, it is important to emphasize those characters which serve to distinguish each unit from others that have been identified. To this end it is desirable to include paragraphs contrasting the characteristics of the unit described with those of "Associated Soils" (soils occurring in the same locality but not necessarily similar) and "Similar Soils" (soils having similar characteristics but not necessarily occurring in the same locality).

In summary, the following outline is recommended for the technical description of soil units:

(a) Name of the soil unit

(b) Introductory paragraph giving higher order classification of the unit (if appropriate) and a brief summary of the essential characteristics of the profile.

(c) Description of an individual profile. The profile chosen should be as representative as possible of the modal concept of the unit and attention should be drawn to any aberrant features which it presents. The description should be prefaced by a short paragraph giving details of the location, relief, slope and vegetation cover of the individual profile.

(d) Accepted range of profile characteristics and of environmental conditions. (Including details of the range in colour, texture, stoniness, etc., as appropriate; drainage; relief; vegetation cover and climate).

(e) Distribution and extent of the soil unit.

(f) Land-use and special management practices. (If not adequately described in the main text).

(g) Associated soils. A paragraph giving a brief description of the names and broad characteristics of soils commonly found associated with the soil described.

(h) Similar soils. A paragraph describing the basis for differentiating other soils having rather similar profile morphology.

(i) Additional remarks. (Technical comments on features of genesis, problems of classification, etc.).

An example soil description, prepared in accordance with this outline is given as Example 2 in the Appendix of this publication.

If laboratory data for the profile described is available this data is best placed with the morphological description to which it refers and comments on this data may be included under the appropriate subheads (see next section).

Appendix III. Soil Analytical Data

A separate appendix of laboratory data is only required if this information cannot be conveniently combined with the descriptions of individual soil units. If the volume of laboratory data is very limited and few of the representative profiles have been analyzed it may be more convenient to tabulate all such data separately. Alternatively, if the volume of data is large, a separate appendix may be desirable to accommodate information additional to that required for the characterization of units. Data on water analysis or comparisons of a purely chemical nature (e.g:- salinity) may also make this appendix necessary.

If all analysis data is included in a single appendix it is helpful to the reader to preface the tables of data with information on the laboratory methods employed. When this is done there is no need to repeat this information in the main body of the text.

Index (or Indices)

Only in reports which are to be printed is the value of an index likely to justify the editorial time required for its preparation. To minimize editorial difficulties indices should be kept as brief as possible, each item considered for inclusion being judged on its likely importance as a reference. In soil survey reports the names of individual soils, reference to specific crops and management practices and references to precise localities most deserve inclusion. In reports relating to very large areas a separate index of place names can be helpful. When several page references are listed against a single index item it is very helpful to print the most informative of these references in bold faced type.

CHAPTER THREE

PLANNING A SPECIFIC REPORT

Early consideration of the requirements of the final report helps to ensure that all necessary data will be collected during the course of a soil survey and that this data will be assembled in a logical manner. Decisions on the development possibilities which need to be investigated, and the consequent selection of criteria to be used in distinguishing kinds of soil, must be based on knowledge of environmental factors which will later be recorded in the report. Systematic collection of such information is one of the first steps in survey procedure. Mention has already been made of the desirability of storing this data in a loose-leaf handbook, grouped in accordance with a preliminary outline of the foreseen report. A report outline to meet the needs of the particular survey can be prepared as soon as the preliminary interpretative aims have been established.

The principles underlying the basic outline which has been described and expanded in previous chapters can be applied in the preparation of all soil survey reports. However, the precise nature of the subject matter, particularly in the interpretative sections, must be planned in relation to the aims of the individual survey. Furthermore, in planning a specific report outline, consideration must be given to the form in which the report is to be published. The basic outline has been designed to meet the most usual circumstances, in which the report will consist of one volume and will record the findings of a single survey. There are, however, other possibilities. Sometimes a survey team will complete several surveys as a single project and will wish to include all findings in a single report having one or more volumes. More frequently the survey forms only part of a project activity and the record of its findings, therefore, forms only part of the project report. The following paragraphs describe how the basic report outline may be adapted to meet these different circumstances.

Reports Published in a Single Volume

(a) Relating to a single survey

The outline, as described, is suitable for reporting upon individual surveys regardless of their scale or purpose. However, the relative importance of different sections and thus, the space which each is allowed to occupy, will vary from survey to survey.

In general, the smaller the scale of mapping the greater is the importance of the description of the environment (Part I). In small scale surveys, the range of environment requiring description is likely to be wider and environmental factors are likely to play a more direct role in distinguishing mapping units. A single sentence may adequately describe some aspect of the environment of a detailed survey which in a report on a reconnaissance survey would be deserving of several paragraphs or even pages.

The space devoted to describing the soils (Part III) should depend on the amount of information available rather than on the scale or purpose of the survey. The author cannot foresee what aspects of the soils data will prove valuable in the future and this section of the report can only be abbreviated by concise writing and by avoiding repetition wherever possible. The more closely related are the mapping units (i.e:- the more detailed is the survey) the greater is the danger of needless repetition.

Alteration of the interpretative part of the report (Part IV) to meet different survey purposes has already been discussed briefly. In detailed surveys it should be possible to consider specific aspects of interpretation in greater detail but the range of interpretation, and thus the number of interpretative chapters, is likely to be limited by the relatively restricted environment.

Even reports on special purpose surveys carried out very rapidly over small areas can follow the general outline proposed although many of the sections may be represented only by sentences or short paragraphs. Brief information on survey and interpretative methods, and on the environment, are no less desirable in such surveys.

(b) Relating to several surveys

It may be necessary to describe several surveys within a single volume. The extent to which separate survey reports can be successfully integrated clearly depends on the number of features which the surveys have in common.

In most cases one Table of Contents; one Glossary; one Introduction and one set of Acknowledgements will suffice for the whole report. Similarly, the Summary of Conclusions and Recommendations should relate to all of the surveys, although here it may be desirable to separate, under suitable sub-headings, conclusions and recommendations arising from specific surveys if they are relevant only to limited areas.

In the remainder of the text some subjects listed in the basic outline may lend themselves to combined description, others will almost certainly have to be treated separately, survey by survey. A subject is worth general discussion if this will reduce repetition in the report as a whole and will clarify relationships between the separate surveys - conditions which are unlikely to be fulfflled if the differences between the surveys in respect to this subject are great. Greater uniformity for purposes of general discussion can sometimes be obtained by grouping the surveys within the report. Geographical or physiographical groupings, which allow for a grouped description of environmental features, are often convenient. Grouping according to the level of survey detail may be more appropriate, however, if such groups reflect important differences in the nature of the data to be described or of survey method.

Thus, three types of subject matter can be recognized in these reports:-

(i) Descriptive material which is relevant to all of the surveys

(ii) Descriptive material which is relevant to a group of the surveys

(iii) Descriptive material relevant only to individual surveys

The material relevant to all surveys should, of course, come first. The sequence of subject matter proposed in the basic outline can be followed. Thus, if appropriate, the first chapter of the text will deal with general environmental conditions in the area enclosing all the surveys. Each aspect (location; climate; physiography, etc.) being discussed in terms of this area as a whole. Comment in detail upon special features of an individual survey area is usually inappropriate here, for the reader is unlikely to remember these details when he reaches the description of the survey later in the text, nor would he look for such data in this part of the report for general reference purposes. If a particular aspect of the environment, such as geology, differs greatly from one survey area to another, it can be dismissed in the general chapter in a single sentence, e.g:-

"Geology in the area is complex and is described in relation to each survey area later in the report".

In the unlikely event that no aspect of the environment is sufficiently general to deserve description at this stage, a general description of survey methods may form the first chapter in the report. It may be necessary to subdivide such a chapter in order to separate differing methods used at different survey scales and the description of some very specialized techniques may be reserved for discussion in connection with the particular survey on which they were used.

The remaining parts of the proposed basic outline can be considered for general discussion in the same way. Discussion of the general properties and even of the principles of classification for the soils of the whole area may be profitable, but the soils of separate surveys are unlikely to be so similar, or so well correlated, as to justify grouping all the individual soil descriptions. The principles of interpretation and the definition of quality classes may be common to all the surveys but the actual interpretation will need to be described survey by survey.

When the possibilities of useful general description have been exhausted, the advantages of grouping the surveys need to be considered. An introductory chapter to each group of surveys can describe those features common to the group.

Finally, within each survey group, come the separate descriptions of the individual surveys, each comprising one or more chapters. The description of individual soil mapping units and their interpretation will form the bulk of these sections but additional notes on "special features of the environment", "special survey methods" etc. may be necessary. In fact, each section will tend to follow the arrangement of the basic outline in an abbreviated form.

Reports Occupying Several Volumes

Rather different considerations apply to the planning of outlines for very lengthy reports which, of necessity, will occupy several volumes. In this situation the space saving advantages of grouping general information are likely to be outweighed by inconvenience to the reader if he is forced to consult more than one volume. Therefore, as far as possible, the data should be grouped by volumes to meet the interests of different groups of readers.

Large survey projects often combine an overall reconnaissance study with more detailed surveys of included areas. The reconnaissance data, of value for broad planning purposes, can form a single volume arranged in accordance with the basic outline and including environmental data for the whole area. The more detailed surveys will interest people concerned with developing feasibility studies for investment and in the actual implementation of development. If all cannot be included in a single volume the detailed surveys should be grouped according to their interpretation possibilities (i.e:- according to their scale and intensity or according to the nature of foreseen development). Description of the groups of surveys can then be arranged in accordance with an adapted version of the basic outline as discussed in the previous section.

As far as possible repetition between volumes should only be permitted when the repeated sections are considered to be essential to the full understanding of the separate volumes. Thus, environmental data for the detailed surveys would refer only to peculiarities of the limited area, with a cross-reference, if needed, to the information in the reconnaissance volume. Again as far as possible technical information relating to specific surveys should be included as appendices to the relevant survey data. If this is inconvenient, however, consideration can be given to the preparation of a separate reference volume containing all data of very specialized interest. This might include detailed information on all survey methods and description of specialized investigations and training programmes.

The editorial work alone required to ensure consistence throughout a very lengthy report is time-consuming. To avoid delay in the release of valuable survey findings it may be desirable to prepare a 'general volume' for advance issue. This would provide a summary of the findings of the survey(s) with emphasis on the interpretative conclusions. The information included in this volume on the general environment, survey methods and the character of individual soils would be reduced to a minimum required to justify and explain the interpretations.

Reports in which Soil Survey Findings Form Only a Part

Brevity and clarity are especially important in reports, such as irrigation feasibility studies, in which the description of soil survey work forms only a part. Each project activity will have claim on the available space and, very probably, amongst potential readers fewer than usual will have any specialized knowledge or specialized interest in the soils. This makes it all the more important to restrict information in the main text to material of value to the general reader and to transfer technical data to a reference appendix.

The principles of the basic outline can be applied to the soils section of the text although interpretative information is likely to be restricted to those development aims which concern the immediate purpose of the project as a whole. Environmental information is likely to appear elsewhere in the report but the author of the soils section must ensure that this information is adequate to support the soils data.

In multi-disciplinary projects co-operation between specialists must extend to the report writing stage. An outline of the overall report should be agreed collectively in advance so that each specialist is aware of the required length and general content of his contribution. All details of mutual interest, notably conclusions and recommendations, must also be discussed and agreed in advance of the report writing stage, if the editor of the overall report is not to be faced with an impossible task of co-ordinating divergent views.

CHAPTER FOUR

STYLE AND PRESENTATION

The author's aim in preparing a soil survey report must be to inform rather than to impress his reader. The success he will achieve will depend, in order of priority, on:-

(a) the way in which the information is arranged;

(b) the clarity and precision of the writing and the extent to which it is adapted to the reader's knowledge and interest;

(c) the attention given to detailed aspects of presentation which determine how easily the reader can find the information that he seeks.

Several of the most important considerations that should influence the presentation of soil survey findings have been discussed in Chapter One. While that discussion need not be repeated, the considerations deserve emphasis and they may be summarized as follows:-

(a) recognition that different aspects of the findings will interest different readers;

(b) clear separation of fact and inference;

(c) clear relationships between text and maps;

(d) the need to establish confidence in the survey findings;

(e) the need to allocate space in the text in proportion to the value of the information.

Other considerations of a more detailed nature are discussed in the following paragraphs.

Repetition

The nature of soil survey findings, calling for the description of inter-related environmental factors and closely related soil bodies, may make some repetition unavoidable and repetition to achieve emphasis is sometimes justified. Nevertheless, the need to reduce repetition to a minimum should be kept in the forefront of the author's mind. Ways of arranging the report to achieve this aim have been described in the previous chapter. Equal care has to be taken in writing individual sections if a satisfactory balance is to be maintained between repetition and continual cross-reference, which may be no less irritating to the reader. Even repeated use of the same words makes tedious reading. The present author has had trouble with 'basic' 'outline', 'report' and 'soil survey' which have tended to intrude too frequently. As another example, repetition of the word 'area' can be irritating, particularly if the reader is uncertain to which of the many 'areas' mentioned in the text reference is being made. Appropriate substitution of words like 'district', 'locality', 'region' or proper geographical names can solve this particular problem. Occasionally, the offending words can be omitted altogether if they relate to the subject under discussion and the context is obvious. At all times the author should accept repetition of words if it is necessary to make his meaning clear and should guard against introducing unusual, archaic or clumsy synonyms which will merely distract the reader.

Subjects to Avoid

Subjects which should not appear in a soil survey report include the author's personal 'gripes'; destructive criticism, especially criticism levelled at personalities or administrations; and comments of a political nature or, indeed, comments on any subject which lies outside the surveyor's field of responsibility. Inclusion of any of this material is clearly undesirable.

This embargo does not prevent the surveyor from making constructive recommendations in his report, even if they refer to the administration and supporting services required for future surveys. His recommendations should be phrased diplomatically, however, to avoid implied criticism as far as possible. The recommendations must be practical and they should relate to matters within the author's sphere of competence.

Criticism of administrative and organizational matters are easy to recognize and avoid. Technical criticism, on the other hand, is more insidious and may be represented by a paternal or patronising style of writing of which the author is scarcely aware. Statements such as "the standard of farming is low" are not helpful and should be replaced by specific recommendations for improvement, e.g:- "greater attention needs to be given to weeding (time of planting, use of fertilizers, etc.)".

Subjects which are the author's pet interest need not be avoided, but they must be kept under careful control. Most soil surveyors tend to develop a special interest in a particular aspect of their discipline, perhaps in soil mineralogy, soil classification or soil micro-morphology. This is commendable, but special studies in these restricted fields can usually be published more appropriately in scientific journals than in soil survey reports. Again, the author may not be aware that he is giving undue emphasis to his personal scientific interest unless he gives the possibility specific consideration.

Concise, Precise and Informative Writing

An author will fail to maintain his reader's interest if his writing is obscure or verbose. The same style of writing cannot be expected to appeal to all readers. Text which is clear to the general reader may seem unnecessarily long-winded and imprecise to the specialist. For this reason, special attention has been given in preceding chapters to defining the kind of readers who are most likely to be interested in different sections of the report. The style of writing in each section should be adapted to the readership for which it is intended.

Concise, crystal-clear writing is essential in the Abstract and in the Summary of Recommendations and Conclusions. Because of their importance and because they must be reasonably short, these sections deserve to be written, and rewritten, until the author is completely satisfied that he has expressed his thoughts to the best of his ability. The suitability of each word should be questioned and the structure of each phrase and sentence disected until the best possible arrangement is achieved and all conceivable ambiguities eliminated.

If the report is ever to appear in print, a less exhaustive approach to the remainder of the text must be accepted. Nevertheless, care must be exercised in the arrangement of phrases and in the choice of words. In general, short words are to be preferred in the main text since they are likely to be meaningful to a larger range of readers. The writer must recognize, however, that short words tend to be less precise in their meaning. Often they carry different meanings in different contexts. In using short words, the writer must be alert to possible misinterpretation and must anticipate a need to include whole phrases, or even sentences, to explain meanings that could be expressed in a single technical word. A few technical words have to be used because their precise meaning is important and because this meaning cannot be explained at length each time the need arises.

The reader should be referred to the Glossary for an explanation of such words on the first occasion they are used. Mere technical jargon, or technical 'slang' (e.g:- 'clay bulge', 'montmorillonite peak'), should be rigorously avoided.

If, as has been recommended, appendices to the soil survey report are regarded as reference material for soil specialists they may include technical words in common scientific usage without additional explanation. Indeed, extensive use of such words will be essential to convey the precise scientific meanings required for reference purposes.

Concise writing:

Concise writing entails a careful watch for words and phrases that add little or nothing to the reader's understanding and careful attention to the arrangement of phrases within sentences.

No gain is achieved if brevity is pursued at the expense of clarity and smooth reading. Long rambling sentences are clearly undesirable. Short sentences wake the reader up but a succession of short sentences makes for disjointed reading. Text built up from a mixture of medium length and short sentences will usually provide the smoothest reading.

Informative writing:

A text may be easily understood whilst conveying only a fraction of the information available to the author. Words, or phrases, of narrow meaning should be chosen where possible because they are more informative as well as more intelligible.

> "A narrow word is nearly always better than a broad word. We hide the picture from the reader if we write "animals" when we mean cattle, or "cattle" when we mean dairy heifers. The name of an object you can see or feel, such as sand, means more than an abstract property such as sandiness. Whenever you write a word with a meaning bigger than the one you want, your reader is almost certain to pick the wrong meaning from it".
>
> "Abstractions come easily when we write about soils and about what people do with soils. People plow, plant and harvest, but we write about soil and crop management. We think about stones, clods or claypan, a steep slope or a shallow soil and we write about limitations. A thin soil horizon here, a thick one there, some chert fragments, a substratum of gravel, and other things can all be referred to as variations."

(Quoted, with the permission of Dr. Charles E. Kellogg, from a draft guide for writers of soils handbooks and soil survey reports; Soil Conservation Service, U.S. Department of Agriculture, 1963).

Imprecise words are tempting to the inexperienced writer. They are comfortably vague and allow him to avoid the research required to state his concepts exactly. Unfortunately, abstract words are rarely helpful and are unlikely to fool any reader who wishes to make practical use of the survey findings. If, for example, we write ".... <u>appropriate</u> (or worse - <u>pertinent</u>) conservation practices must be used", we are merely insulting the reader. If he knows which practices are appropriate he will surely use them, if he does not, he may conclude that the author is equally ignorant, or lazy, or both.

Precise information may not, in fact, be informative to the reader unless its significance is explained. For example, in many reports the written description of individual soils includes numerical data on chemical characteristics. To many readers these details will be meaningless, unless some indication of their significance is

provided. If the data is very significant in relation to interpretations given elsewhere in the report the data must be included, but it should be possible to indicate in what way the values recorded are noteworthy - as a minimum, are they high or low? If, on the other hand, such data merely forms part of the routine soil characterization, it would be better placed in an appendix. Numerical data on slopes, on specific aspects of climate, or relating to other environmental factors may need similar brief explanations to be truly informative.

Detailed Aspects of Presentation: Headings and Subheadings

Every effort should be made to assist the reader to find the information he is seeking. This entails grouping all closely related subject matter together and providing informative headings and subheadings to identify each subject. Each major theme deserves a heading, minor themes a subheading and each line of thought within a minor theme deserves a separate paragraph. In general, paragraphs should be reasonably short. The reader may have difficulty in referring back to important points if they are buried in long paragraphs. Nevertheless, to preserve the thread of a single lengthy argument, an occasional long paragraph may be desirable.

The drafting of headings deserves careful thought. To be useful as references they must accurately reflect the contents of the section to which they refer, bearing in mind that their meaning may be less obvious when they appear out of context in the Table of Contents. Yet, at the same time, individual headings should be as brief as possible.

To assist the reader in understanding the structure of the report the relative importance of various headings must be clearly and consistently differentiated throughout the text. This may seem a minor point and yet it reflects a very common failing in drafts propared by inexperienced writers. In a printed text different styles of type can be used to distinguish different orders of headings, but even so, the printer must be guided by a clear differentiation of headings in the author's typescript. In typescript, the relative importance of headings can be differentiated easily following three simple rules:-

(a) Headings which are centred on the page are more important than headings which start at the left margin.

(b) Headings which are underlined are more important than headings which are not.

(c) Headings written entirely in capitals are more important than headings in which only the more important words start with capitals which, in turn, are more important than headings which have only a capital for their initial letter.

These rules are written in their own order of importance. Thus, centering is more important than underlining, and underlining is more important than the use of capitals. By combining these rules it is easy to distinguish as many 'orders' of heading as are likely to be required. Difficulty lies in being consistent throughout the text. This can only be achieved by careful editing.

Similar considerations apply to the numbering of paragraphs or of items presented in list form. In very short reports consecutive numbering of all paragraphs (with Arabic numbers) can assist cross-reference. Alternatively, a decimal system can be used, with whole numbers assigned to major sections and decimal numbers to subsections of descending importance (2, 2.1, 2.11 etc.). If more than two places of decimals are used, however, such a system tends to become more confusing than helpful. In most soil survey reports numbering of all paragraphs is impractical, but numbering (or lettering) of minor sections and of listed items to emphasize their close relationship can be helpful. Again, it is important to be consistent. Capital letters or Roman numerals are appropriate for major divisions of the text whilst Arabic numbers, lower case letters or lower case Roman

numerals can be used to distinguish subdivisions. In this publication, for example, lower case letters (a, b, c) have been used for primary subdivisions and lower case Roman numerals (i, ii, iii) for secondary subdivisions.

CHAPTER FIVE

MAPS

Maps and text should form complementary parts of a soil survey report. A discussion on reporting methods would be imcomplete if the contribution of either was ignored. It has been suggested in Chapter One that the text acts in a supporting role supplying information that cannot be conveniently included on the maps, but this does not imply that the maps can be planned without reference to the needs of an informative text. Carefully planned mapping legends can provide subject headings for the text which will ensure the clear relationship desired between text and map. Furthermore, well-planned maps can greatly reduce the volume of explanatory writing required.

This chapter, therefore, is concerned, not with cartographic techniques,[1] but with those aspects of planning, designing and presenting maps that are of special importance in preparing a well-rounded soil survey report.

PLANNING MAP REQUIREMENTS

A preliminary assessment of the number and nature of maps to be included in the report is required at a very early stage in soil survey planning. Budget estimates must take account of map proposals since graphic work is likely to be costly in relation to other publication expenses, especially if coloured maps are required. Work plans must make allowance for assembling base materials, collecting information, cartography and printing if a realistic time schedule of operations is to be foreseen. Account must also be taken of future availability of maps in drafting the proposed report outline, assessing which aspects of information are best presented in graphic or written form. Both budget and work plans must be sufficiently flexible as to allow the introduction of additional, or alternative, maps if need is recognized as the work proceeds.

Economies in map production can be achieved by:-

(a) reducing the range of subjects illustrated by separate maps

(b) reducing the scale and thus the size (and possibly the number of sheets) of individual maps

(c) limiting the use of colour.

Each of these possibilities will now be considered in more detail.

Choice of Subject Matter for Maps

There is little doubt that good maps provide the most effective way of presenting survey data, whether it be basic data on the distribution of soils or interpretative data illustrating the relative potential of specific areas for differing purposes. Ideally, separate maps should be prepared to illustrate each field of interpretation. The more

---

1/ A reader who requires basic information on the preparation of graphical material is referred to either of the following books:-

1. Monkhouse, P.J. and Wilkinson, H.R. "Maps and Diagrams"; Methuen & Co. Ltd. London; Second Edition, 1963.
2. Robinson, A.M.; "Elements of Cartography"; John Wiley & Sons, Inc. New York, Second Edition, 1959.

specific the field of interpretation, the more valuable is a map likely to be to a specialized group of readers. The size of this readership group is less important than the size of the contribution that they may be able to make, with the assistance of the map, towards the development of the region. Each map should be judged, therefore, on the basis of its potential contribution to development.

Once the potential contribution of a map has been evaluated this must be weighed against the difficulties involved in its preparation. This involves consideration of the availability of suitable base maps, the problems of graphic representation of data, and the availability of required skills, facilities, finance and time. Finally, available time, facilities and finance must be apportioned between those maps offering greatest potential.

Savings in production costs can often be effected by combining information on a single map. Paradoxically, this can sometimes be achieved without sacrificing the aim of keeping interpretative information as specific as possible. A single grouping of basic soil units may often be appropriate for different interpretative purposes, although the significance of the groups may differ for each purpose. In this situation, separate legends on a single map can supply specific interpretative information for two, or more, purposes. Similarly, if the basic soil map is not too complex, interpretative groupings can sometimes be superimposed, preferably by the use of colour groupings, with the addition of interpretative symbols and an interpretative legend. This adaptation of the basic soil map should be avoided if possible, however, since the 'useful life' of the basic and interpretative data is likely to differ. The basic soil map can be used more appropriately to show the sites of described and analyzed soil pits and the situation of any sampling traverses.

In addition to maps which present the survey findings, the text of a soil survey report usually includes maps of an explanatory or background nature. These maps are usually small and no major saving can be effected by their exclusion. Nevertheless, each should be evaluated, particularly in relation to the contribution which they make in reducing and clarifying the text. Again attention should be given to combining information - for example, hydrology with climate, geology with geomorphology, population with communications - care being taken in each case to avoid overcrowding.

Choice of Publication Scale

A reduction in scale between field mapping sheets and the published maps is usually foreseen in soil survey. Indeed, such reduction is usually desirable in that it ensures that the positioning of soil boundaries, in relation to topographical detail shown on the published maps, has a high standard of reliability. In modern soil surveys, in which the use of air photographs permits very accurate location of observations in relation to surface features, publication at the scale of the field sheets is often acceptable. Occasionally, it may be convenient to enlarge the soil map <u>together with its topographic base</u> to permit the addition, or planning, of other activities such as the engineering design of irrigation or drainage works. In no circumstances, however, should soil boundaries be transferred from field sheets to separate base map of larger scale, since the relationship of the boundaries with the additional topographic detail of the larger maps is likely to be totally unreliable.

While accepting some reduction in the scale of his maps for publication and recognizing the factors which make this desirable, the soil surveyor <u>should strongly resist</u> economic pressures that may seek to reduce his maps to sizes which will seriously reduce their value. After all, the cost of map production is usually very small in relation to the overall cost of a soil survey.

If we neglect constraints that may be dictated by available facilities, the factors which need to be considered in choosing a publication scale include:-

(a) the purpose for which the map is intended

(b) considerations of convenience and economy in publication

(c) considerations of convenience in using the map

(d) aesthetic considerations

Aesthetic considerations can be dismissed quickly, although their importance should not be underestimated. To be attractive a published map should look neither too empty nor too full. If a map is attractive it is more likely to draw and hold attention.

Apart from being unnecessarily expensive, maps published at an excessively large scale may be unsightly and will be awkward to fold or handle. Therefore, considerations of convenience, both in publication and in use, usually dictate that a minimum scale be chosen. An exception arises when a series of maps at a certain scale already exists in the country. Use of this scale will facilitate comparison and correlation of information on other maps of the series, even if these are concerned with subjects other than soil. It will also be more economical if existing printing plates for the topographical base can be used.

The minimum publication scale is governed by the purpose that the map is required to fulfil. The scale chosen must be large enough to show the required detail, which, in turn, is largely governed by two considerations;

(a) the minimum area of interest to planners

(b) the precision with which boundaries must be located

Of course, these criteria will have been considered in planning the actual intensity of the survey but they must not be forgotten at the publication stage.

The minimum area of planning interest is defined by the nature of the development which is envisaged. In detailed surveys it should be defined by the planners themselves, taking account of the size of units which, for practical and economic reasons, need to be uniformly developed. Soil variations which will effect the distribution of the smallest of such units, and will dictate their separate development possibilities, must be shown. If, for example, the map is to be used for planning development and conservation of individual farms, the scale must be sufficiently large as to distinguish significant differences in soil in individual fields. At semi-detailed and reconnaissance intensities of survey, development possibilities will only be revealed by the survey itself and the surveyor must then decide the minimum area which can usefully be distinguished for the planner.

In practice, the minimum area which can be shown on a map of given scale is not easy to define. Much depends on the shape of the small area, the general complexity of the map, including the density of topographic detail, and the complexity of the mapping symbol which must be enclosed within, or clearly related to, the small area. Table 1 shows the area represented by one square centimetre on maps of different scale. At each scale it should be possible to indicate areas of about half this size but if many such areas have to be shown, a larger publication scale would be preferable.

TABLE 1: Area represented by 1 sq. centimetre on Maps of different scales

Scale of Map	Area represented by 1 sq. centimetre	
	Metric Units	Imperial Units (Approximately)
1: 2,500	625 sq. metres	750 sq. yards
1: 5,000	0.25 hectares	0.6 acres
1: 10,000	1 hectare	2.5 acres
1: 20,000	4 hectares	10 acres
1: 25,000	6.25 hectares	15.5 acres
1: 50,000	25 hectares	62 acres
1: 100,000	1 sq. kilometre	247 acres
1: 200,000	4 sq. kilometres	1.5 sq. miles
1: 250,000	6.25 sq. kilometres	2.4 sq. miles
1: 500,000	25 sq. kilometres	9.7 sq. miles
1: 1,000,000	100 sq. kilometres	38.6 sq. miles

The required precision of bouardaries depends on the degree of contrast between adjacent areas and the significance of this contrast in relation to development. If the map is to be used for engineering purposes, including the design of irrigation and drainage layouts, a high degree of precision is necessary. Precision demands a large publication scale if the exact location of boundaries in relation to topographical detail is to be shown.

There is a temptation to choose a scale large enough to show every distinction which the surveyor has been able to map. This viewpoint has some justification in relation to basic soil maps since it is difficult to foresee what information will prove of value in the future. Provided field sheets are carefully preserved, however, no information need be lost and the published sheets can be presented at a scale that will adequately show all information known to be of immediate significance. On interpretative maps, in particular, the inclusion of insignificant data confuses the picture and may even mask differences of major planning consequence.

Similar considerations apply to the choice of scale for maps which are included in the text for explanatory purposes. Wherever possible a standard scale should be used for such maps throughout the report to facilitate comparison. However, their size and to a large extent their scale is governed by the page size of the text and their value and appearance can only be improved by careful choice of content.

The size of lettering, and to a lesser extent, the definitions and complexity of lines and stipples on the master draft of a map, set practical limitations on the possibilities of photographic reduction at the printing stage. These difficulties should be foreseen. The final publication scale and any desirable photographic reduction to achieve this scale should be agreed with the editor and the printer before the master draft is prepared. The minimum height of lettering that is comfortably legible is about 1 mm. Therefore, if a reduction of 2:1 during printing is proposed, height of lettering on the master draft should not be less than 2 mm. If possible, the printer's advice should be obtained on suitable stipple patterns that will not break, blur or block when printed at the reduced scale.

In preparing master drafts for reduction the surveyor may need to simplify the boundaries on his field sheets. Wriggles that will be difficult to reproduce and may not be meaningful at the smaller scale need to be smoothed and very small delineations should be eliminated or, if necessary, replaced by symbols.

Wherever possible, simple numerical ratios based on the metric system (e.g:- 1: 5,000) should be chosen as scales for publication. The scales listed in Table 1 are particularly appropriate for soil survey maps of differing intensity.

The published scale should be recorded on each map sheet. A scale bar (linear scale) should always be shown since this is not invalidated by reduction during printing. Additional scale representation in the form of a numerical ratio is desirable, however, since this is more immediately informative to the user. Scale representation in both forms should be possible on all maps that present survey findings, for which accurate reproduction to a predetermined scale is usually stipulated. Precise scale is rarely important for explanatory maps and, given some latitude in this respect, the printer can arrange such maps to best effect. On these maps a scale bar alone suffices.

Choice Between Colour and Monochrome Maps

A decision to publish maps in colour rather than in monochrome should not be lightly taken, since colour reproduction is so much more expensive and time-consuming, especially if facilities for such work are not locally available. The need to use colour should be judged in relation to each separate map, or map series. The criteria to be considered in making this judgment include:-

(a) the number of separate mapping units and the complexity of their pattern

(b) the way in which the map will be used

(c) the anticipated useful life of the map

(d) the number of copies required

Soil maps very often depict a complex pattern of numerous separate mapping units. The problem of adequately distinguishing these units can be very severe, particularly if it is desired to give an overall impression of the more important aspects of soil distribution as well as to identify individual units. Units can be distinguished by the use of colour; by symbols; or by rulings and stipples, which are available in the form of adhesive transparencies in a wide range of patterns. Frequently all three methods have to be used. On many basic soil maps the use of colour to avoid excessively complex combinations of symbols and monochrome patterns is almost essential. For reasons of clarity it is rarely desirable to use more than six or seven different monochrome patterns on a single map sheet.

The way in which a map is to be used has an important bearing on the choice of means to be employed in distinguishing mapping units. If the map is of a detailed nature and will be used by people familiar with the area, its primary purpose will be to provide information on specific localities. The user will only be interested in identifying the relatively small number of units to be found in a certain part of such a map. An appropriate symbol in each mapping unit will serve this purpose and will not obscure topographical detail of importance in locating the precise position of boundaries. However, mapping units identified only by symbols provide no impression of the general distribution of soils which may be required on smaller scale maps intended for broader planning purposes. If the number of separate units is small, which is often the situation with interpretative maps, they can probably be adequately distinguished with appropriate rulings or stipples. Indeed, if the stipple patterns are carefully chosen the quasi-quantitative distinctions desired on interpretative maps can be achieved. The densest patterns may be appropriate for areas of highest promise, grading through less dense patterns for successive classes of diminishing value. On the other hand, contrasting patterns of similar tone value (e.g:- small crosses as opposed to dots) can be used to distinguish units of equivalent significance - different soils on a simple basic soil map, for example.

The addition of colour can simplify the use of a map or broaden its useful applications. Colour can be used to emphasize features of importance or to relate mapping units having characteristics in common, thus revealing the broader relationships of soil distribution. Colour may also be superimposed to permit an entirely separate use for the map - coloured interpretative classes superimposed on a basic soil map, for example. Thus, the extent to which it will enhance the usefulness of a particular map needs to be considered in deciding whether the expense of colour reproduction is justified.

Considerations of 'useful life' and of the number of copies required are especially significant in relation to the use of colour for interpretative maps. Clearly, if the interpretative information is likely to become quickly outdated or if it is only of interest to a limited bumber of users, multi-coloured reproduction, which is extremely expensive for short print-runs, can scarcely be considered. Coloured interpretative maps may be justified if the information they convey is exceptionally important and a need exists to extend this information by visual impact to a wide range of people. Basic soil maps at small and medium scales can be expected to retain their value for a long period and, if coloured reproduction is necessary, a relatively large first printing taking account of future needs will reduce the cost of individual map sheets.

From the preceding discussion it will be apparent that colour can be used effectively without employing the whole spectrum. Indeed, in the interests of economy, the number of colours used on a single sheet should be kept to a minimum. Much can be done with only two or three colours if used in combination with patterns of rulings or stipples. Superimposed colours should be avoided because of the expense in preparing and correcting colour proofs. Gradations of single colours do not present this problem. If an extensive map series is foreseen, it is worth taking a lot of trouble to design, in consultation with the printer, a system of coloured patterns that can be applied uniformly to corresponding units on all sheets of the series.

MAP LEGENDS AND SYMBOLS

Map Legends

The aim of a map legend is to make the map self-explanatory. In designing a legend this aim should be clearly recognized and every effort should be made to achieve it. In other words, each mapping legend should be as comprehensive as the space available allows. If need be, the overall size of a map sheet should be increased to allow space for an adequate legend. If the map is already too large, or if it extends to several sheets, less satisfactory solutions are to print the legend on a further sheet or to use the back of the map(s) for this purpose. Some means must be found to provide an adequate legend which can be conveniently carried with the map into the field, where basic and interpretative soil maps at all but the smallest scales are most useful. The user will be greatly inconvenienced if he has to make continual reference to the report text in order to understand the maps.

The legend should be designed to be informative to the widest possible range of users. On a basic soil map, for example, it is not sufficient to identify the mapping units in terms of complex taxonomic names, meaningful only to specialists; or in terms of locally named kinds of soil, possibly meaningful only to the surveyor and his immediate colleagues. Both kinds of names may have their place in a soil map legend but they require to be supplemented with a brief explanation of the most significant characteristics of the soils they represent. Similarly, on interpretative maps it is not sufficient to identify the interpretative units solely by class numbers (e.g:- Class I; Class II; Class III etc.) without briefly defining the practical significance of these classes. The provision of adequate explanation on interpretative maps should be relatively easy since the number of separate units is rarely large, but this simple step is very frequently overlooked in preparing such maps.

Of course, it may not be possible within the legend to explain all the considerations and specifications which strictly define each mapping unit. It is reasonable to expect the user to have studied the report text before he attempts to use the map. The map legend then reminds the reader of the most significant aspects of the classification portrayed. If important criteria have to be omitted from the legend, such as management considerations on an interpretative map, it may be desirable to include a footnote to the legend drawing attention to these omissions.

On basic soil maps showing many separate units it is helpful to group these units in the legend, reclassifying them in effect at one or more higher levels of generalization. This grouping in the legend will emphasize relationships between units by showing some of the characteristics which some of the units have in common, whether or not the colouring and patterns of the map also reflect these relationships. The basis of grouping may be in accordance with different levels of an accepted taxonomic soil classification. It will usually be impossible, however, to explain the significance of all the names used at different levels of such a classification within the confines of a map legend. This means that the grouping of the legend will only be of value to soil specialists. Unless such specialists form a major proportion of the expected users of the map, a different basis for grouping is preferable (taxonomic grouping can always be discussed in the text). Physiographic distinctions, expressed in terms that will be self-explanatory to a wide range of users, often provide a satisfactory basis for grouping soil units at various levels of generalization. It may be convenient to use different criteria for the various levels of grouping but throughout any one level of generalization the basis of grouping must be consistent if the groups are to be mutually exclusive. Ephemeral characteristics of the soil (such as levels of salinity) or of the environment (such as minor differences in vegetation) should not be used as a basis for grouping.

In planning the grouping of mapping units in the legend and in devising titles for these groups, consideration should be given to the suitability of these titles as subheads for subdivisions of the explanatory text. If the same titles can be used, the significance of explanations in the text will be clarified and their value correspondingly increased.

In addition to providing information on the resource units depicted, the legend of a resource map must also explain conventional signs and other aspects of the topographic base in sufficient detail to ensure that the user will have no difficulty in locating his position on the map. Some topographic conventional signs have little relevance to this purpose and these can be excluded from the soil map legend.

Map Symbols

It is usual to identify each unit on a soil map with a symbol consisting of one, or more, letters and/or numbers. Two kinds of such symbols can be recognized:-

(a) Simple symbols consisting of very few letters or numbers which serve only to identify the unit and to relate it to the map legend. For this purpose, it is convenient to use mnemonic groups of letters, representing an abbreviation of the name of the soil unit, which the map user can hope to remember without continual reference to the legend.

(b) Complex symbols which serve the additional purpose of providing information on the characteristics of the unit - each letter or number in the symbol describing the expression of a particular characteristic in accordance with a key.

The use of complex symbols is attractive since they appear to offer a means of showing a large amount of information about each mapping unit. Nevertheless, complex symbols have important disadvantages and they should be used with great caution. Disadvantages include:-

(i) Symbols which include a large number of characters present practical problems in the design and reproduction of maps. If individual characters are to be large enough to be legible it may be very difficult to accommodate the whole symbol within mapped boundaries. Experience shows that keying symbols to small units by means of arrows creates very real dangers of misinterpretation and adds to the complexity of the map, obscuring topographic detail. The whole map may have to be published at a larger scale to accommodate the symbols, although the intensity of observation may not justify use of this larger scale. The longer and more complex the symbol, the greater is the likelihood of error in transferring data from field sheets at the compilation stage. The resulting increase in editorial work and map correction can lead to a very marked increase in compilation time and costs. From this practical viewpoint it is desirable to limit most map symbols to two or three characters and only in exceptional circumstances should more than five characters be used.

(ii) It may be difficult to relate an adequate map legend to complex symbols. If each character in the symbol reflects a different kind of information and there are many such characters it may be impossible to accommodate a legend large enough to explain the full range of each character. It will certainly be impossible to explain the nature of each of the many units represented by combinations of these characters. Similar difficulties exist in relating units identified by complex symbols to explanatory material in the text. The significance of differences in each of the soil features reflected by a character in the symbol can be explained, but the reader is left to evaluate the interactions between these features himself. To avoid these difficulties complex symbols are sometimes constructed from a simple symbol, representing whole kinds of soil which can be grouped and described as usual in text and legend, plus additional characters intended to represent more specific information. If the user must make continual reference to the report text to understand the meaning of these additional characters they will be little used.

(iii) The information conveyed by complex connotative symbols is likely, at best, to be an oversimplification of the nature of the soil. It may be possible to express differences in an individual soil characteristic in terms of a simple range of classes but the practical significance of these differences can rarely be judged without reference to other soil characteristics. Furthermore, characteristics which provide important practical distinctions within one group of soils may be relatively unimportant in another group in the same survey area. Connotative symbols cannot express the complex relationships which are taken into account by the soil surveyor in correlating and contrasting areas of soil.

(iv) The use of complex symbols in mapping encourages the development of an uncontrolled soil legend. Even if only a small number of criteria, each having a limited range of differentiated expressions, is selected for symbolic representation, the number of possible combinations is very large. Only a specialist familiar with the area could decide which combinations of characters are significantly different for practical purposes and reliable correlation of units is almost impossible. The dangers of an uncontrolled legend that include an almost unlimited number of possible units is discussed in some detail on pages 317-319 of the U.S. Soil Survey Manual (1951).

Despite these disadvantages, the use of complex symbols may be appropriate on very detailed soil maps where the user will be concerned with obtaining maximum information about specific localities rather than a broad appreciation of soil distribution. This is especially true in surveys carried out to provide guidance for irrigation or drainage development, in which the expression of certain individual soil characteristics has special significance.

With discretion, a limited number of connotative symbols can also be used to distinguish phases of main soil units - i.e:- differences of slope, surface stoniness, erosion etc. which are of practical importance but which are not diagnostic characteristics of the mapping units themselves.

PREPARING MAPS FOR PUBLICATION

Maps require very careful editing before they are submitted for publication. It would be a rare map that included no errors or omissions in its first fair draft stage. Only the surveyor has the necessary knowledge to make some of the corrections which are likely to be needed. Even he may have difficulty, unless the maps are perfected while the work is fresh in his mind and while he has access to the required information. The following errors are very common and can rarely be corrected by any but the surveyor:-

(a) Mapping units lacking identifying symbols.

(b) Open boundaries and omitted boundaries between units bearing different symbols.

(c) Lack of correspondence between boundaries and/or mapping units on adjacent map sheets.

(d) Lack of correspondence between mapping units, symbols and legend.

All these faults can usually be identified and corrected if the soil surveyor himself hand colours one set of maps, including the legend - whether or not the final maps are to be coloured. At the same time the surveyor should check the exact correspondence of units and symbols on the fair draft and on the field sheets. This last step is especially important if complex connotative symbols are employed.

The surveyor should also check:-

(a) that the map bears a title which accurately reflects the subject matter and location of the map;

(b) that a linear scale is shown and is correct;

(c) that the numerical scale, if shown, will be correct after stipulated reduction;

(d) that a 'north point' is correctly shown. Normally 'True North' will be indicated. If 'Magnetic North' is shown, the date of the map and average magnetic variation in the area on that date should also be given;

(e) that the legend includes all necessary explanation of conventional signs;

(f) that the spelling of geographical names on the map is that adopted by the competent government authority in the country concerned;

(g) that acknowledgement of the source of the topographic base or of other details is given, if necessary. This is especially important when copyright material, for which acknowledgement is required, has been included;

(h) that, if appropriate, a disclaimer regarding territorial and other boundaries shown on the map is included. For example, the following disclaimer is printed on FAO maps:-

"The designations employed and the presentation of the material in this map do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimination of frontiers."

In preparing his maps for publication the surveyor should also consider whether they should show:-

(a) an inset location map of the survey area including, if appropriate, a guide to adjacent map sheets;

(b) a reliability diagram, illustrating variations in the intensity or nature of observations on which the mapped data is based;

(c) details of the projection or grid on which the map is drawn (particularly for small scale maps).

REFERENCES

Klingebiel A.A. and Montgomery P.H. "Land-Capability Classification" Agricultural (1961) Handbook No. 210, Soil Conservation Service, U.S. Department of Agriculture.

F.A.O. "Guidelines for Soil Description": Food and Agriculture Organization (1968) of the United Nations, Rome.

U.S. Bureau of Reclamation "Land Classification: Irrigated Land-Use, Vol. V, part 2, (1953) Bureau of Reclamation Manual, U.S. Department of the Interior.

U.S. Soil Conservation Service "Soil Survey Manual", Agricultural Handbook No. 18, Soil (1951) Conservation Service, U.S. Department of Agriculture.

---------- "Guide for Writers of Soils Handbooks and Soil Survey Reports" (draft). (1963) Soil Conservation Service, U.S. Department of Agriculture.

A P P E N D I X

The following examples have been drafted to illustrate the intended differences between methods of soil description considered appropriate for use in the main text (i.e:- in Chapter Four of the basic outline - Example 1) and in the appendix of a soil survey report (Example 2). The former is intended for the general reader, the latter for the soils specialist. The former description relates to geographic areas of soil represented by mapping units on the soil map, the latter to a taxonomic concept.

The soils and locations described are imaginary but, to facilitate comparison of presentation, the same soils are described in each example.

Note should be taken of the emphasis placed in both examples on the characteristics which distinguish the soils described from adjacent or similar soils identified in the area. This information is desirable if the reader is to fully appreciate the basis of interpretation and is <u>essential</u> if he is to recognize the soils described in the field.

Example 1: Narrative description of soils for inclusion in the main text

An extract from the chapter describing soil mapping units (Chapter Four in the basic outline) in a report of a detailed soil survey, in which it is assumed that individual soil series were mapped and grouped into soil associations based on drainage and parent geology, might read as follows:-

"1. Well Drained Soils derived from Coarse Grained Granitic Rocks - Chapa Association

The soils mapped in this association form the most extensive group of soils in the area surveyed, occupying approximately 2,400 acres (45% of the entire area). All the soils have free internal drainage and the groundwater table remains below a depth of 150 cms. at all times of the year. All the soils appear to be derived directly, or indirectly, from underlying coarse grained granitic gneisses and pegmatites, rich in quartz and felspar but poor in dark ferro-magnesian minerals. In the area surveyed these rocks have given rise to a gently undulating topography in which the range of elevation between summit and valley floor rarely exceeds 20 metres and maximum slopes do not exceed 5%. This topography is characteristic of the association in the survey area and can be readily distinguished on aerial photographs.

The upper horizons of the soils, above a depth of about 20 cms. are usually rather sandy in texture, brown in colour, and contain few, if any, stones or coarse gravel. In upper slope sites these horizons overlie a clearly defined stone/gravel layer, which extends to a depth of about 100 cms. On concave slopes at lower levels in the topography the stone/gravel layer, if present, is buried beneath a much deeper layer of wash material derived from higher sites. A variety of textures is found in the stone/gravel layers but they are rarely very clayey and are often very sandy. The colour of the soil matrix in this layer ranges from light brownish grey to reddish brown, the reddest colours being associated with the finer textured soils in the highest topographical sites. All the soils of the association contain a rather high proportion of coarse sand and very fine gravel throughout their profile and quite large fragments of felspar and white mica are usually present within 100 cms. of the surface. Soft, friable weathered rock material, clearly displaying evidence of the original rock structure occurs within 150 cms. of the surface in most profiles and fresh rock is usually encountered at depths between 200 and 250 cms. Between the gravel layer and the weathered rock material there is usually a layer of brightly mottled clay showing no rock structure other than veins of resistant quartz. Mottled clay is not well developed in soils of this association, however, and the thickness of the mottled layer rarely exceeds 50 cms.

Five soil mapping units, named after the soil series which is predominant within them, have been distinguished in this association in the present survey. The distribution of these soils shows a clear relationship with topography. The sequence of mapping units from summit to lower slope sites is as follows:-

Convex, upper slopes;	Rogor series Chapa series
Concave, lower slopes;	Irego series Kako series Apopo series

In fact, the shallow soils over hard ironstone, mapped as Kako series, may occur within areas mapped as either Irego or Apopo series. Their presence is often marked by a sharp change in the lower slope gradient.

Rogor Series

This mapping unit occupies summit and upper slope sites and, apart from a very few inextensive rock outcrops, encloses soils which conform with the modal concept of Rogor soil series (see detailed description in Appendix II). The unit occupies only 3% of the surveyed area.

In conformity with the general description of soils of the Chapa association given previously, soils of the Rogor series have a shallow surface layer of stone-free rather sandy material (usually sandy loam) overlying a well defined stone/gravel layer containing fragments of felspar between depths of about 20 and 100 cms. The topsoil to a depth of 6 to 8 cms. usually has a texture of fine sandy loam largely composed of material derived from large worm casts which cover the surface; and is very dark in colour, particularly in areas subject to annual burning. Within the gravel layer, at a depth between 20 and 30 cms. there is a marked increase in clay content and coatings of clay on the structural units of the soil below this depth provide clear evidence of vertical clay movement and clay accumulation (i.e:- a 'textural B' horizon). Separate horizons, apart from the stone/gravel layer, are not very clearly defined. These soils remain friable to a depth of at least 100 cms. at all times of the year.

By arbitrary definition, soils of the Rogor series have a texture which is not less clayey than sandy clay within a control horizon between 20 and 50 cms. below the surface and the colour of the soil matrix in the lower part of the gravel layer is yellowish red, reddish brown, or red (i.e:- either 2.5 YR or 5 YR hues in the Munsell colour system). These characteristics serve to distinguish the soils from the more sandy, less red but otherwise similar soils of the Chapa series which are often adjacent.

Below the gravel layer, soils of the Rogor series usually display a thin development of brightly mottled clay, rarely more than 30 cms. thick, which grades into weathered rock material showing evidence of original structure at depths between 120 and 150 cms. The presence of this weathered rock material within two metres of the surface, together with the content of coarse sand, fine gravel and felspar fragments, serves to distinguish soils of the Rogor and Chapa series from upper slope soils of other soil associations in the survey area.

Laboratory analysis of these soils (Appendix II) shows that, under natural vegetation, they are well supplied with plant nutrients (high base saturation, neutral pH, fairly high content of exchangeable bases), particularly in the surface horizon. Their capacity to retain nutrients is not high, however, (rather low exchange capacity). Therefore, their nutrient content can be easily depleted, or imbalanced, by intensive cropping or injudicious fertilization. A reserve of nutrients is present at depth (presence of unweathered minerals, pH steady or rising with depth) and can be exploited by deep rooting crops or fallows. Following grass fallow the availability of nitrogen is low (high C/N ratio in surface horizons) so that cereal crops, in particular, can be expected to show large responses to nitrogen fertilizer. Moderate responses to phosphatic fertilizers can also be expected. The soils are well supplied

with potassium.[1/]

At present, the soils of this mapping unit are used mainly for arable farming, although there are a few small areas of cocoa under planted shade trees and banana. The main crops are yams (Dioscorea spp.) and guinea corn (Sorghum vulgare) but some maize is also grown. Minor crops such as local beans and melon are usually interplanted. Cassava is commonly planted in the third year of cultivation before the 'farm' is allowed to revert to the natural high grass fallow. Annual burning prevents the re-establishment of forest which, probably, would otherwise be the natural vegetation of the mapping unit. The potential of the land in this mapping unit is discussed in Part IV.

No variants or phases of the Rogor series were mapped in this survey.

Chapa Series

This mapping unit occupies upper slope sites below soils of the Rogor series, or summit sites where the Rogor series is absent. The sum of the areas mapped as belonging to this unit represents 25% of the survey area, making it the most extensive unit recognized. Soils conforming with the modal concept of Chapa series (see detailed description in Appendix II) account for 85% of the area enclosed by the unit. Rock outcrops, which are larger and more frequent than in the Rogor mapping unit account in total for a further 10% of the unit. In addition, a sandy variant could not be mapped separately at the intensity of survey employed.

By definition soils of the Chapa series do not have a texture finer than sandy clay loam within a control horizon between 20 and 50 cms. below the surface and the colour of the soil matrix in the lower part of the stone/gravel layer is brownish yellow, yellowish brown or reddish yellow (i.e:- either 7.5 YR or 10 YR hues in the Munsell colour system). In other respects, the morphological characteristics of soils of the Chapa series are essentially similar to those of the Rogor series just described.

In general, soils of the Chapa series are more sandy than Rogor series (loamy sand between depths of 8 and 25 cms.) but profiles typical of the series show sandy clay loam at depths of about 40 cms. and sandy clay at about 60 cms. depth. Six exposures (representing about 5% of the area mapped in this unit) showed a texture of sandy loam to a depth of over 60 cms. These were recognized as a sandy variant of the Chapa series but could not be mapped separately.

Laboratory analysis (Appendix II) shows the nutrient status of these soils to be slightly inferior to that of Rogor series as is to be expected with their sandier texture.

Present land-use on this mapping unit is very similar to that of the Rogor unit, except that cocoa does not perform successfully on these soils and very few cocoa plantings have survived. The potential of the unit is described in Part IV.

Irego Series

Soils of this mapping unit etc. etc. etc.... "

1/ Much of the contents of this paragraph might apply to the soils of the survey area in general, in which case they would have been presented in the previous chapter of the report and would not be repeated here. Alternatively, if appropriate, they might be included in the description of the association as a whole.

Example 2: Detailed technical soil description for inclusion in report appendix

The following example illustrates a technical soil description considered appropriate for inclusion in the appendix of a soil survey report where it will serve as a source of reference for specialist readers. It relates to one of the series described in the previous example. This example is derived from the FAO publication "Guidelines for Soil Description".

"

Chapa Series

The Chapa series are Ferruginous Tropical Soils (Typic Tropudalfs in the revised 7th Approximation). They are deep, well drained soils and are characteristically brown to strong brown in colour with a textural B containing fairly large quantities of quartz and ironstone gravel. Structural development is weak and horizonation ill defined.

Typical Profile

The following profile was examined in a specially prepared pit, 50 metres south of milepost 70 (near Chapa Village) on the main road from Port Cabot to Gamaville, North-western Atlantis. (Approximately 6° 12'S. 15° 30'E.). The site was on a convex summit in gently undulating country under a vegetation of tall grass fallow following arable cultivation.

A_1	0 - 10 cm.	Very dark greyish brown (10 YR 3/2) moist and dark greyish brown (10 YR 4/2) dry, fine sandy loam; weak to moderate medium and fine crumb; slightly sticky slightly plastic, very friable moist, slightly hard dry; many fine and medium interstitial pores; many large worm casts on the surface; abundant fine and few medium roots; clear, smooth boundary; pH 6.4.
A_2(?)	10 - 20 cm.	Brown to dark brown (7.5 YR 4/4) moist and brown (7.5 YR 5/4) dry, sandy loam; very weak fine sub-angular blocky to structureless; slightly sticky, non plastic, very friable moist, loose dry; many very fine interstitial pores; very frequent fine and medium roots; gradual, smooth boundary; pH 6.2.
B_1	20 - 40 cm.	Brown (7.5 YR 5/4) moist and only slightly paler dry, gravelly sandy clay loam; weak to very weak, fine sub-angular blocky breaking very easily to very fine aggregates; slightly sticky, non plastic, very friable moist, soft dry; common fine interstitial pores; frequent, fine, angular quartz gravel (1.0 to 1.5 cm.) and few, small, hard, spherical black ironstone nodules; few fine and medium roots; gradual, smooth boundary; pH 6.2.
B_2t, cn	40 - 100 cm.	Brown to strong brown (7.5 YR 5/5) moist and dry, gravelly sandy clay; weak medium sub-angular blocky; slightly sticky, slightly plastic, friable moist, soft dry; patchy thin and moderately thick cutans on some ped faces but mainly in old root channels probably of clay with iron oxides; common fine and medium interstitial pores and few fine random (but mainly vertical) inped tubular pores; few, fine angular

quartz gravel (1.0 to 1.5 cm.) and very few, angular quartz stones (8 to 12 cm.); few, small hard, spherical black ironstone nodules; few medium roots; gradual, smooth boundary; pH 6.4.

B_3	100 - 130 cm.	Reddish yellow (7.5 YR 6/6) moist gravelly sandy clay; structureless massive but breaking very easily to very fine aggregates; slightly sticky, slightly plastic, friable to firm moist; no detectable cutans; gravel content similar to horizon above; frequent very small angular fragments of felspar; very few fine roots; gradual, smooth boundary; pH 6.4.
C_1	130 - 180 cm.	Light brown (7.5 YR 6/4) moist, common, medium and coarse, distinct pink, yellowish red, reddish yellow and white mottles, slightly gravelly sandy clay loam; massive; slightly sticky, slightly plastic, firm moist; few, fine angular quartz gravel, very frequent very small fragments of felspar; few, soft, somewhat irregular dark red ironstone nodules, gradual, smooth boundary; pH 6.4.
C_2	180 - 200/215 cm.	Pinkish grey (7.5 YR 7/2) moist coarse sandy laom; structureless; non sticky, non plastic; loose moist; few, fine angular quartz gravel; frequent irregular fragments (0-5 to 5 cm.) of a strongly weathered gneiss; clear, wavy boundary.
R_2	200/215 cm. +	Slightly weathered granitic gneiss.

(Note: This profile is slightly finer in texture in the A_2(?) and B_1 horizons than is usual in the series as a whole.)

Range of Characteristics

a. Profile characteristics. The series is well drained. Thickness of the solum (to the bottom of B_2t) ranges from 80 to 150 cm. Texture and colour of the A horizons are variable. Texture in the B_1 horizon (about 20 - 50 cm. depth) ranges from sandy loam to sandy clay loam. Texture in the B_2 horizon (about 40 - 100 cm. depth) is not coarser than sandy clay loam and is usually sandy clay. Colour in the B horizon is not redder in hue than 7.5 YR. Reaction range is neutral to slightly acid, pH increasing with depth. Substantial quantities of both quartz and ironstone gravel are always present in the B horizons. Rock is normally encountered at a depth ranging from 150 to 250 cm. from the surface.

b. Environmental characteristics. The soil occurs in upper slope and summit sites and appears to be derived exclusively from coarse grained granitic gneisses under a natural vegetation of tall grass savanna (probably a 'fire climax'). The soil has been encountered under annual rainfall ranging from 800 to 1,100 mm, with uniformly high mid-day temperatures - over 26°C. (80°F.) - and a pronounced dry season from November to mid-March.

Distribution and Extent

The soil is restricted to upper slope and summit sites in the rolling country fringing the eastern border of North Western Atlantis. Although individual occurrences are quite small the series as a whole occupies about 300 square miles.

Associated Soils

Soils of Chapa series are usually associated with gravel free soils of Apopo and Irego series, which occupy lower topographical sites, and with poorly drained soils of Joko and Adum series in the valley bottoms. Occasionally similar soils of Rogor series (see below) are associated, usually in higher topographical sites. In some areas, shallow soils over indurated plinthite, Kako and Nago series, are also associated.

Similar Soils

The only soils of similar morphology occurring in the same vegetation zone are those of Rogor and Arena series. Soils of Rogor series are finer in texture, (sandy clay within 50 cm. of the surface) and redder in colour (2.5 YR and 5 YR hues). Those of Arena series are more sandy in texture (not finer than loamy sand to 50 cm.) and are usually gravelly to the surface. Soils with almost identical morphology to Chapa series, but differing in chemistry and immediate potential, are found under forest vegetation in the coastal zone and are classified separately as Pongo series.

Additional Remarks

Biological activity is considered to play an important part in the morphology of these soils. In many areas, earthworm activity is very pronounced, the surface of the soil being completely covered with large wormcasts (up to 5 cm. long). Termite hills are common in the area and the gravel-free surface horizons are probably a reflection of termite activity. "