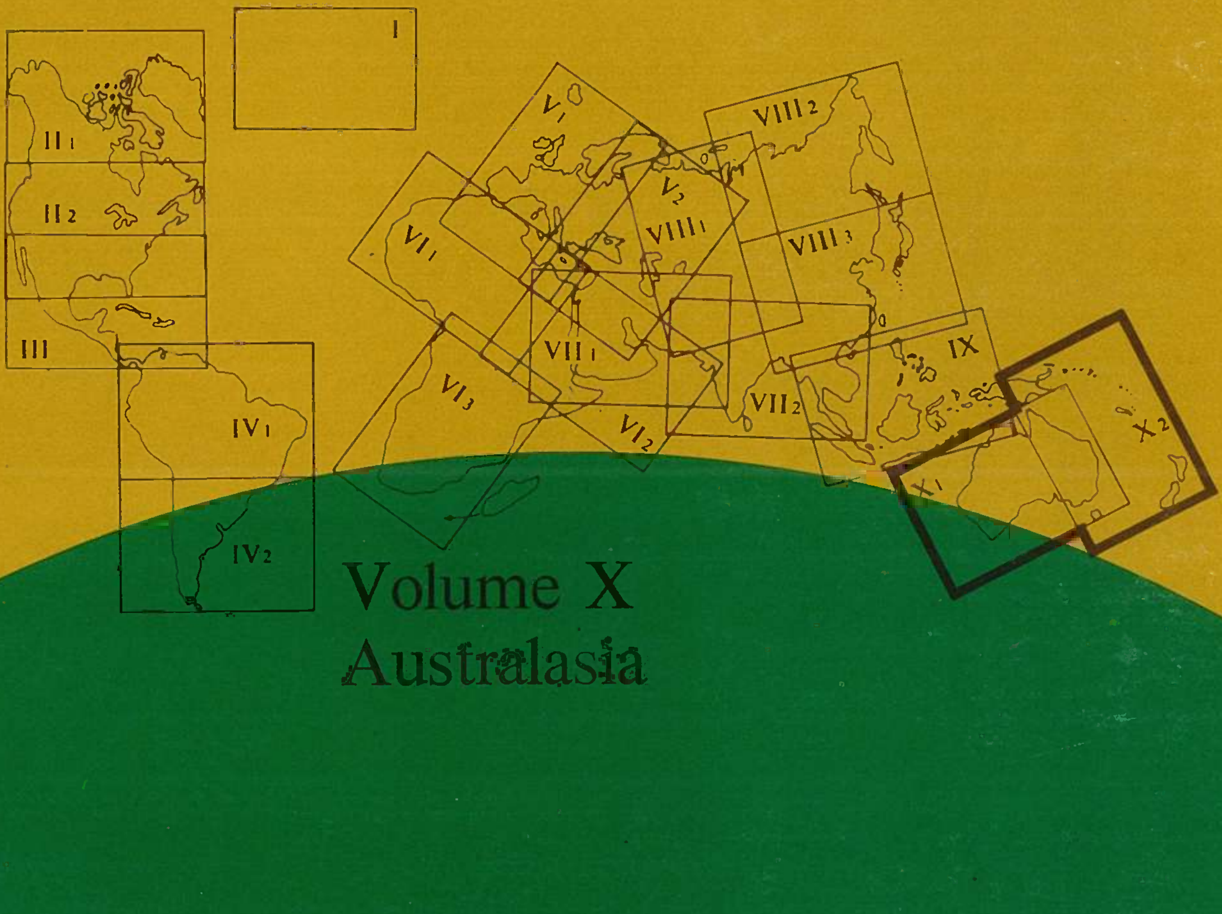
FAO-Unesco

Soil map of the world

1:5 000 000



Volume X
Australasia

Unesco

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Soil map of the world

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

FAO-Unesco

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1 : 5 000 000

Volume X
Australasia

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PREFACE

The project for a joint FAO/Unesco Soil Map of the World was undertaken following a recommendation of the International Society of Soil Science. It is the first attempt to prepare, on the basis of international cooperation, a soil map covering all the continents of the world in a uniform legend, thus enabling the correlation of soil units and comparisons on a global scale. The project, which started in 1961, fills a gap in present knowledge of soil potentialities throughout the world and provides a useful instrument in planning agricultural and economic development programmes.

The project has been carried out under the scientific authority of an international advisory panel, within the framework of FAO and Unesco programmes. The different stages of the work included comparative studies of soil maps, field and laboratory work, and the organization of international expert meetings and study tours. The secretariat of the joint project, located at FAO headquarters, was vested with the responsibility of compiling the technical information, correlating the studies and drafting the maps and text. FAO and Unesco shared the expenses involved in the realization of the project, and Unesco undertook publication of its results.

The present volume, covering the soils of Australia, Papua New Guinea, New Zealand and the islands of the Pacific ocean, is the last of a set of ten which make up the complete publication of the Soil Map of the World. The first volume records introductory information and presents the definitions of the elements of the legend which is used uniformly throughout the publication. Each of the nine following volumes comprises an explanatory text and corresponding map sheets covering the main regions of the world.

FAO and Unesco wish to express their gratitude to the government institutions, the International Society of Soil Science, and the many individual soil scientists who have contributed so much to this international project. They particularly wish to thank the Government of New Zealand for contributing most of the cost of publishing the maps and text volume for the Australasia and Pacific region.

CONTENTS

SUMMARY

This volume describes the Australasia and Pacific section of the 1 : 5 000 000 Soil Map of the World. The Soil Map of the World is a joint FAO-Unesco project initiated in 1961. The Australasia and Pacific section was compiled between 1970 and 1975.

The maps

The two map sheets, X1 and X2, which make up the Soil Map of Australasia and the Pacific are drawn on topographic base maps of the 1 : 5 000 000 series of the American Geographical Society. Sheet X1 covers Australia, and sheet X2 covers Papua New Guinea and the southwest Pacific, including the Solomon Islands, the New Hebrides, New Caledonia and New Zealand. Soil maps of Fiji, Samoa, Tonga and Hawaii are shown as insets. Soil data on the other islands and island groups in the east Pacific, in Polynesia, Micronesia and Melanesia, and the nontropical islands and Antarctica, are given in the text.

The map units are associations of soil units divided into texture and slope classes. They are marked on the map by symbols. The dominant soils are shown by colours while phase differences are shown by overprints.

A small inset map on sheet X1 indicates three grades of reliability of soil information from which the map was compiled.

Detailed definitions of the soil units and full descriptions of all the terms used may be found in Volume I of the set.

The text

The first chapter outlines the history and objectives of the project, and discusses the value and limitations of the map and the use of the map and text. Chapter 2 acknowledges the cooperation of the many agencies and people who contributed to the maps and text. Chapter 3 summarizes from Volume I details of the map units and their cartographic representation, and indicates the sources of soil information obtained from the various countries in the region.

ENVIRONMENTAL CONDITIONS

Chapter 4 contains brief accounts, with some maps, of the four factors of the environment that have close relationships with the pattern of soils: climate, vegetation, physiography and lithology.

Climate is discussed on the basis of climatic elements, and maps are included showing annual rainfall, seasonal rainfall, temperature and evaporation patterns for the Australian continent (Figures 2-5). Rainfall regimes of Papua New Guinea are also illustrated (Figure 6). To link climatic patterns with those of other volumes of the Soil Map of the World the broad climatological-agricultural regions of the classification of Papadakis are included with maps of Australia, Papua New Guinea and New Zealand (Figures 7-9).

Vegetation of Australia is described in 19 units, the distribution of which are shown on a map (Figure 10). Soil and plant nutrient relationships are also discussed. Notes are added on the vegetation of Papua New Guinea, the Solomon Islands, New Caledonia, New Zealand and the oceanic islands.

Physiography of Australia is treated in terms of landscapes with a map of landforms and geomorphic provinces (Figure 11). The landforms of Papua New Guinea, the Solomon Islands, New Caledonia, New Zealand and the oceanic islands, which are important for an understanding of the distribution of soils, are also described.

Lithology of Australia is illustrated with a map of the main rock types (Figure 12), and very briefly described in terms of continental structures. The lithologies of Papua New Guinea, the Solomon Islands, New Caledonia, New Zealand and the oceanic islands are also discussed.

SOILS

Chapter 5 describes the *distribution of the major soils* in 11 broad structural and ecological units, each of which has a characteristic pattern of soil distribution. The main soils of each unit are discussed in relation to environmental factors. The soils are highly varied in nature and distribution but it appears that most countries have soil resources capable of substantially improved production. There are real limitations to be overcome before the potential of many soils can be achieved, but with the present soil knowledge, and with the possibilities for regional cooperation in practical research now available, these limitations should steadily be reduced in the coming years.

Included in Chapter 5 is an extensive table of *soil associations* in which all the map units are listed in alphabetical order of symbols. Other columns show:

Associated soils
Inclusions
Phases
Areas of units in 1 000 ha
Climate
Countries of occurrence
Vegetation and present land use
Lithology: parent material, landform, elevation.

SOILS AND LAND USE

Chapter 6 contains notes on the soil characteristics, distribution and land use of 58 of the main soils of the region. Possibilities for agricultural development are noted.

OTHER PACIFIC REGIONS

Chapter 7 deals with the soil units of the Pacific regions not shown on the map. These are east Pacific, Polynesia, Melanesia, Micronesia, the non-tropical islands and Antarctica. A table similar to that in Chapter 5 is included.

Appendix

An appendix gives site and profile data, including profile descriptions and analyses, for 44 soils which are important in the region.

RÉSUMÉ

Le présent volume décrit la section Australasie et Pacifique de la Carte mondiale des sols au 1/5 000 000. La Carte mondiale des sols a été entreprise en 1961 dans le cadre d'un projet conjoint FAO/Unesco. La section Australasie et Pacifique a été compilée entre 1970 et 1975.

Les cartes

Les deux coupures, X1 et X2, qui composent la carte des sols de l'Australasie et du Pacifique ont été dressées sur les fonds de cartes topographiques de la série exécutée au 1/5 000 000 par l'American Geographical Society. La coupure X1 couvre l'Australie et la coupure X2 la Papouasie Nouvelle-Guinée et le Pacifique du Sud-Ouest, y compris le protectorat britannique des îles Salomon, les Nouvelles-Hébrides, la Nouvelle-Calédonie et la Nouvelle-Zélande. Les cartes des sols des Fidji, Samoa, Tonga et Hawaii figurent en médaillons. Les données pédologiques concernant les autres îles et groupes insulaires du Pacifique Est, la Polynésie, la Micronésie, la Mélanésie, les îles non tropicales et l'Antarctique sont incluses dans le texte.

Les unités cartographiques sont des associations d'unités pédologiques divisées en classes de texture et de pente. Sur la carte, elles sont indiquées par des symboles. Les sols dominants sont représentés par des couleurs, tandis que les différences de phases apparaissent en surimpressions. Sur la coupure X1, on a indiqué dans un petit médaillon les trois classes de fiabilité des informations pédologiques d'après lesquelles la carte a été compilée.

Le volume I de la série donne les définitions détaillées des unités pédologiques et des descriptions complètes de tous les termes utilisés.

Le texte

Le premier chapitre décrit l'historique et les objectifs du projet et examine la valeur et les limitations de la carte ainsi que l'utilisation qui peut être faite de la carte et du texte. Le chapitre 2 contient des remerciements à l'adresse des nombreuses institutions et personnes qui ont coopéré et contribué à l'établissement des cartes et du texte. Le chapitre 3 résume les données détaillées contenues dans le volume I concernant les unités cartographiques et leur mode de représentation, et indique la provenance des informations pédologiques obtenues des divers pays de la région.

LE MILIEU

Le chapitre 4 contient de brefs comptes rendus, ainsi que quelques cartes, des quatre facteurs écologiques qui sont en étroite relation avec le système des sols: climat, végétation, physiographie et lithologie.

Le *climat* est traité sur la base des éléments climatiques; des cartes montrent les précipitations annuelles et saisonnières, la configuration des températures et de l'évaporation pour le continent australien (figures 2-5). Une autre illustration (figure 6) montre les régimes pluviométriques de la Papouasie Nouvelle-Guinée. Pour rattacher les systèmes climatiques avec ceux des autres volumes de la Carte mondiale des sols, on a inclus les grandes régions agro-climatiques de la classification de Papadakis, avec des cartes de l'Australie, de la Papouasie Nouvelle-Guinée et de la Nouvelle-Zélande (figures 7-9).

La *végétation* de l'Australie est décrite en 19 unités, dont la distribution est représentée sur une carte (figure 10). On a étudié également les relations entre les sols et les nutriments des végétaux. Des notes supplémentaires traitent de la végétation de la Papouasie Nouvelle-Guinée, des îles Salomon, de la Nouvelle-Calédonie, de la Nouvelle-Zélande et des îles océaniques.

La *physiographie* de l'Australie est traitée du point de vue des paysages, avec une carte des formes de relief et des provinces géomorphologiques (figure 11). Les formes de relief de la Papouasie Nouvelle-Guinée, des îles Salomon, de la Nouvelle-Calédonie, de la Nouvelle-Zélande et des îles océaniques, qui sont importantes pour comprendre la distribution des sols, sont également décrites.

La *lithologie* de l'Australie est illustrée par une carte des principaux types de roches (figure 12) et décrite très brièvement du point de vue des structures continentales. On a étudié également la lithologie de la Papouasie Nouvelle-Guinée, des îles Salomon, de la Nouvelle-Calédonie, de la Nouvelle-Zélande et des îles océaniques.

SOLS

Le chapitre 5 décrit la *distribution des principaux sols* en onze grandes unités structurales et écologiques, dont chacune possède un schéma caractéristique de distribution des sols. Les principaux sols de chaque unité sont traités par rapport aux facteurs écologiques. Les sols varient considérablement quant à leur nature et à leur distribution, mais il semble que la plupart des pays possèdent des ressources pédologiques susceptibles d'une production substantiellement améliorée. Un certain nombre de limitations réelles devront être surmontées avant que l'on puisse réaliser le potentiel de nombreux sols mais, avec les connaissances pédologiques et les possibilités de coopération régionale d'ores et déjà disponibles en matière de recherche pratique, ces limitations devraient régulièrement reculer dans les années à venir.

Dans le chapitre 5, on trouvera un tableau étendu des *associations de sols*, dans lequel toutes les unités cartographiques sont énumérées par ordre alphabétique des symboles. Dans les autres colonnes figurent les indications ci-après:

Sols associés
Inclusions
Phases
Superficie des unités (en milliers d'hectares)
Climat
Pays
Végétation et utilisation actuelle des terres
Lithologie: matériaux d'origine, forme de relief, élévation.

LES SOLS ET L'UTILISATION DES TERRES

Le chapitre 6 contient des indications concernant les caractéristiques et la distribution des sols ainsi que l'utilisation des terres correspondant à 58 des principaux sols de la région. Les possibilités de développement agricole sont indiquées.

AUTRES RÉGIONS DU PACIFIQUE

Le chapitre 7 traite des unités pédologiques des régions du Pacifique qui n'apparaissent pas sur la carte. Il s'agit du Pacifique Est, de la Polynésie, de la Mélanésie, de la Micronésie, des îles non tropicales et de l'Antarctique. Un tableau semblable à celui du chapitre 5 est inclus.

Annexe

En annexe, on trouvera des données relatives aux sites et aux profils, y compris des descriptions et analyses de profils, pour 44 sols importants de la région.

РЕЗЮМЕ

Этот том посвящен разделу Австралазии и Тихого океана Почвенной карты мира в масштабе 1:5.000 000. Почвенная карта мира является объединенным проектом ФАО-ЮНЕСКО, начатым в 1961 г. Раздел Австралазии и Тихого океана составлялся в 1970-1975 гг.

Карты

Два листа карты, X1 и X2, которые составляют почвенную карту Австралазии и Тихого океана, подготовлены на основе топографических карт масштаба 1:5.000 000 серий Американского географического общества. Лист X1 охватывает Австралию, а лист X2 охватывает Папуа-Новую Гвинею и юго-западную часть Тихого океана, включая Британский протекторат Соломоновых островов, Новые Гебриды, Новую Каледонию и Новую Зеландию. Почвенные карты островов Фиджи, Самоа, Тонга и Гавайских островов приведены на вкладышах. Почвенные данные по другим островам и группам островов в восточной части Тихого океана, Полинезии, Микронезии, Меланезии, а также нетропическим островам и Антарктики приводятся в тексте. Картографические единицы соответствуют почвенным единицам, разделенным по классам механического состава и рельефа. Они обозначены на карте. Основные почвы указываются различными цветами, а разновидности указываются штриховкой.

Маленькая карта-вкладыш к листу X1 указывает три уровня достоверности информации о почвах, на основе которой составлялась карта.

Детальные определения видов почвы и полное описание всех примененных терминов можно найти в томе 1 этой подборки.

Текст

В первой главе изложены история и цели проекта и указаны значение и недостатки карты и применения карты и текста. Во второй главе подтверждается сотрудничество многих учреждений и лиц, которые внесли свой вклад в составление карт и текста. В третьей главе кратко излагаются данные из тома 1 разделов карты и приводится их картографическое изображение, указываются источники информации о почвах, полученной из различных стран региона.

Условия окружающей среды

В главе 4 приведены краткие справки с некоторыми картами по четырем факторам окружающей среды, которые тесно связаны с образцами почв: климат, растительность, физическая география и литография.

Климат описывается на основе климатических элементов и включенные карты указывают годовые осадки, сезонные осадки, температуру и модели испарения для австралийского континента (схемы 2-5). Режимы осадков в Папуа-Новой Гвинее также указаны (схема 6). Для связи климатических моделей с другими моделями, входящими в другие тома Почвенной карты мира, в карты Австралии, Папуа-Новой Гвинеи и Новой Зеландии включены широкие климатическо-сельскохозяйственные районы классификации Парадакиса (схемы 7-9).

Растительность Австралии описана в 19 разделах и их распределение указано на карте (схема10). Также описывается взаимосвязь почвы и пищевых растений. Добавлены замечания о растительности Папуа-Новой Гвинеи, Соломоновых о-вов, Новой Каледонии, Новой Зеландии и океанических островов.

Физическая география Австралии излагается с точки зрения ландшафтов с картой формы поверхности и геоморфических провинций (рис. 11). Описаны также формы поверхности Папуа-Новой Гвинеи, Соломоновых островов, Новой Каледонии, Новой Гвинеи и океанических островов, которые важны для понимания распределения почв.

Литология Австралии иллюстрируется картой основных типов скальной породы (схема 12) и очень кратко описана в отношении континентальных структур. Также описана литология Папуа-Новой Гвинеи, Соломоновых о-вов, Новой Каледонии, Новой Зеландии и океанических островов.

Почвы

В главе 5 дается описание распределения основных почв в 11 основных структурных и экологических группах, каждая из которых имеет характерную модель распределения почвы. Основные почвы каждой группы рассматриваются в связи с факторами окружающей среды. Почвы в высшей степени разнообразны по своей природе и распределению, но оказывается, что большинство стран имеют почвенные ресурсы, способные значительно повысить продуктивность. Существуют реальные ограничения, которые нужно преодолеть для того, чтобы использовать потенциальные возможности многих почв, но при современных знаниях почв и при доступных в настоящее время возможностях для регионального сотрудничества в практических исследованиях, эти ограничения следует в ближайшие годы постоянно сокращать.

В главу 5 включена широкая таблица почвенных соединений, в которых перечислены все картированные виды в алфавитном порядке обозначений.

Другие колонки показывают:

Сопутствующие почвы
Спорадические
Разновидности
Области единиц в 1.000 га
Климат
Страны залегания
Растительность и современное использование земли
Литология: материнская порода, рельеф, подъемы

Почвы и использование земли

В главе 6 содержатся заметки о характеристиках почв, их распределении и использовании земли по 58 основным почвам этого региона. Отмечаются возможности сельскохозяйственного развития.

Другие районы Тихого океана

Глава 7 касается почвенных единиц районов Тихого океана, не указанных на этой карте. Это восточная часть Тихого океана, Полинезия, Меланезия, Микронезия, нетропические острова и Антарктика. Включена таблица, подобная таблице в главе 5.

Приложение

В приложении приводятся данные о местонахождении и профилях, включая описания и анализы профилей по 44 наиболее важным для этого региона почвам.

RESUMEN

En este volumen se describe la sección de Australasia y el Pacífico del Mapa Mundial de Suelos a escala 1 : 5 000 000. El Mapa Mundial de Suelos es un proyecto conjunto FAO-Unesco inciado en 1961. La sección de Australasia y el Pacífico se compiló entre 1970 y 1975.

Los mapas

Las dos hojas X1 y X2 que constituyen el Mapa de Suelos de Australasia y el Pacífico se han trazado sobre los mapas topográficos base de la serie a escala 1 : 5 000 000 de la American Geographical Society. La hoja X1 abarca Australia y la X2 Papua Nueva Guinea y el sudoeste del Pacífico, incluido el Protectorado de las Islas Salomón británicas, las Nuevas Hébridas, Nueva Caledonia y Nueva Zelandia. Los mapas de los suelos de Fiji, Samoa, Tonga y Hawaii se muestran como recuadros. Los datos sobre los suelos de otras islas y grupos de islas en el este del Pacífico, Polinesia, Micronesia, Melanesia y las islas no tropicales, así como la Antártica, se dan en el texto.

Las unidades del mapa son asociaciones de unidades de suelos divididas en clases texturales y de inclinación. Se indican en el mapa por medio de símbolos. Los suelos dominantes se muestran por colores, mientras que las diferentes fases se indican con sobreimpresiones.

Un pequeño mapa inserto como recuadro en la hoja X1 indica tres grados de fiabilidad de la información sobre la que se compiló el mapa.

En el Volumen I de la serie pueden encontrarse las definiciones detalladas de las unidades de suelos y descripciones completas de todos los términos utilizados.

El texto

El primer capítulo esboza la historia y objetivos del proyecto y expone el valor y las limitaciones del mapa, así como el uso de éste y del texto. En el segundo capítulo se da cuenta de la cooperación de los muchos organismos y del gran número de personas que han colaborado en los mapas y en el texto. En el Capítulo 3 se presenta un resumen del material contenido en el Volumen I en cuanto a unidades de mapas y su representación cartográfica y se indican las fuentes de información obtenidas de los diversos países y regiones.

CONDICIONES DEL MEDIO

El Capítulo 4 contiene breves reseñas con algunos mapas de los cuatro factores del medio que guardan una estrecha relación con la estructura de los suelos: clima, vegetación, fisiografía y litología.

El *clima* se estudia sobre la base de los elementos climáticos, incluyéndose mapas que muestran la pluviosidad anual y estacional, la temperatura y el régimen de evaporación para el continente australiano (figuras 2-5). También se ilustra el régimen pluviométrico para Papua Nueva Guinea (Figura 6). Para vincular los regímenes climáticos con aquellos de otros volúmenes del Mapa Mundial de Suelos, las amplias regiones climatológico-agrícolas de la clasificación de Papadakis se incluyen con los mapas de Australia, Papua Nueva Guinea y Nueva Zelandia (figuras 7-9).

La *vegetación* de Australia se describe dividida en 19 unidades, cuya distribución se muestra en un mapa (Figura 10). Se examinan también las relaciones entre suelos y nutrientes de las plantas. Se añaden notas sobre la vegetación de Papua Nueva Guineas, Islas Salomón, Nueva Caledonia, Nueva Zelandia y las islas oceánicas.

La *fisiografía* de Australia se trata en función de paisajes con un mapa de formas del terreno y provincias geomórficas (Figura 11). También se describen las formas de la tierra de Papua Nueva Guinea, Islas Salomón, Nueva Caledonia, Nueva Zelandia y las islas oceánicas que son importantes para una comprensión de la distribución de los suelos.

La *litología* de Australia se ilustra con el mapa de los tipos principales de rocas (Figura 12) y se describe muy brevemente en función de estructuras continentales. Se examinan también las litologías de Papua Nueva Guinea, Islas Salomón, Nueva Caledonia, Nueva Zelandia e islas oceánicas.

SUELOS

En el Capítulo 5 se describe la *distribución de los suelos principales* en 11 unidades amplias estructurales y ecológicas, cada una de las cuales tiene un régimen característico de distribución de suelos. Los principales suelos de cada unidad se estudian en relación con los factores ambientales. Los suelos son de naturaleza y distribución altamente variable, pero al parecer casi todos los países poseen recursos de suelos capaces de una producción notablemente mejorada. Existen limitaciones reales que vencer antes de que el potencial de muchos suelos pueda ser logrado, pero con el conocimiento actual de los suelos y con las posibilidades de cooperación regional en investigación práctica con que hoy se cuenta estas limitaciones deberían irse reduciendo gradualmente en los años venideros.

Incluido en el Capítulo 5 figura un cuadro extenso de *asociaciones de suelos*, en las cuales se enumeran todas las unidades de mapas en orden alfabético de símbolos. Otras columnas muestran:

Suelos asociados
Inclusiones
Fases
Superficie de las unidades en millares de hectáreas
Clima
Países en que se presentan
Vegetación y utilización actual de las tierras
Litología: material de partida, forma del terreno, altitud

LOS SUELOS Y EL USO DE LA TIERRA

El Capítulo 6 contiene notas sobre las características de los suelos, distribución y utilización en 58 de los principales suelos de la región. Se hacen observar las posibilidades de fomento agrícola.

OTRAS REGIONES DEL PACÍFICO

El Capítulo 7 trata de las unidades de suelos de las regiones del Pacífico no representadas en el mapa. Estas son el Pacífico oriental, la Polinesia, la Melanesia, la Micronesia, las islas no tropicales y la Antártica. Se incluye un cuadro análogo al que figura en el Capítulo 5.

Apéndice

En el Apéndice se recogen datos de lugares y perfiles incluidos análisis y descripciones de perfiles de suelos para 44 suelos importantes en la región.

1. INTRODUCTION

History of the project[1]

Recognizing the need for an integrated knowledge of the soils of the world, the Seventh Congress of the International Society of Soil Science, held at Madison, Wisconsin, United States, in 1960, recommended that ways and means be found for the publication of soil maps of the great regions of the world. As a follow-up to this recommendation, FAO and Unesco agreed in 1961 to prepare jointly a Soil Map of the World based on the compilation of available soil survey material and on additional field correlation. The secretariat of the joint project was located at the headquarters of FAO in Rome. It collected and compiled the technical information, undertook correlation studies, and drafted the maps and text.

In June 1961 an advisory panel composed of prominent soil scientists representing various parts of the world was convened by FAO and Unesco to study the methodological, scientific and various other problems related to the preparation of a Soil Map of the World.[2]

Between 1961 and 1968 work progressed steadily on the preparation of definitions of soil units and on the development of draft soil maps of the various continents. At the Ninth Congress of the International Society of Soil Science in Adelaide, Australia, in 1968, soil maps of all parts of the world were on display for evaluation and discussion by members. The display included a new map of Australia at a scale of 1 : 2 000 000, and a new map of New Zealand at 1 : 5 000 000 in which the Soil Map of the World legend was used.

During the Congress and the subsequent tours, discussions took place on the correlation of the units of the soil map of Australia with those of the Soil Map of the World. These were continued by correspondence and taken up again at a meeting of Australian and New Zealand soil scientists in Adelaide at the end of 1969. At this meeting responsibilities for the preparation of various sections of the maps and text were decided. In 1970 the work of assembling the information began.

Progress on the Pacific islands section of the map was taken a substantial step forward in 1971 at meetings during the Twelfth Pacific Science Congress in Canberra, Australia. Soil scientists from the Solomon Islands, Fiji, New Zealand, Papua and New Guinea, and the United States Trust Territories were present, and Prof. G. Aubert, a member of the Advisory Panel of the Soil Map of the World project, was able to represent the French Territories. Consultations continued in New Caledonia after the Congress and were maintained by correspondence.

The contributors completed their material in 1972 and this was assembled into draft maps and text by the end of 1973. After further discussions the final documents were completed in 1975.

The main sources of information are described and acknowledged in Chapter 3.

Objectives

Transfer of knowledge and experience from one area of the earth to another can only be successful when allowance is made for similarities and differences in the geographical, soil and climatic conditions of the regions or countries involved. Furthermore, the economic feasibility of different management techniques under prevailing socioeconomic conditions needs to be assessed before they can be recommended for adoption. Reliable information on the nature and distribution of the major soils of

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[1] This section refers mainly to the preparation of the Soil Map of Australasia and the Pacific. The history of the project as a whole is dealt with more completely in Volume I.

[2] The participants at this meeting were:

Consultants: G. Aubert (France), M. Camargo (Brazil), J. D'Hoore (Belgium), E.V. Lobova (U.S.S.R.), S.P. Raychaudhuri (India), G.D. Smith (United States), C.G. Stephens (Australia), R. Tavernier (Belgium), N.H. Taylor (New Zealand), I.V. Tiurin (U.S.S.R.), F.A. Van Baren (Netherlands).

Unesco Secretariat: V.A. Kovda and M. Batisse.

FAO Secretariat: D. Luis Bramão, R. Dudal and F. George.

the world is thus of fundamental importance. However, the preparation of regional and continental soil maps requires a uniform legend and nomenclature and the correlation of existing soil classification systems. One of the principal objectives of the FAO/Unesco Soil Map of the World project was to promote agreement among soil scientists all over the world on an international soil correlation system.

In Australia, New Zealand and Hawaii agricultural science is highly developed, and the soils and their potentialities for production are well known. In the Pacific, also, many areas have a substantial record of agricultural research, and this is being actively pursued with the aim of expanding the growth of food and other crops for the rapidly increasing population. Many experts under international and bilateral programmes are assisting the governments in this task. This regional soils study attempts to present a first synthesis of the knowledge available at the present stage of development of soil science in Australasia and the Pacific. It is hoped that it will promote better understanding among soil scientists, planners and farmers, provide useful coordination of national and international soils work, and stimulate research and its application in the region.

Value and limitations of the map

The Soil Map of Australasia and the Pacific is meant to be a source of factual data, providing a basis and framework for further regional and national soil surveys at a more detailed scale. It may assist in selecting methods for reclamation, crop production, fertilizer application, and general use of soils. Up until now all attempts to make overall plans or forecasts for agriculture have been hampered by lack of uniformity in the terminology, nomenclature and classification of soils and by lack of a comprehensive picture of the world's soil resources.

Through a systematic interpretation of the Soil Map of the World it will be possible to make an appraisal of the distribution and the production potential of the major soils on a continental or regional basis and to delineate broad priority areas which deserve further study. This inventory of soil resources will bring to light the limitations and potentialities of the different regions for increased food production.

In addition, a regional soil map such as the Soil Map of Australasia and the Pacific can be a valuable teaching aid for the training of geographers, soil scientists, agronomists and all those who are involved with the study of the environment.

Although the publication of the map and text marks a significant step forward, it is necessary to point out its inherent limitations. The accuracy and detail of the information which can be shown are obviously limited by the small scale of the map and by the fact that soil data for some areas are scarce because of inadequate field correlation or lack of direct observations. Difficulties were encountered in the compilation of the regional map because of the differences in the methods of field and laboratory studies. These limitations may also apply to the interpretative data, since they can only be as accurate as the soil information on which they are based. Despite these shortcomings, this soil map is the most recent and detailed inventory of soil resources based on international cooperation. Its limitations emphasize the necessity for intensified soil correlation and for obtaining better knowledge of the nature and distribution of soils in those parts of the region where information is lacking or inadequate.

On the southern margin of the Pacific basin is Antarctica, a continent double the size of Australia. Here the soils are limited in distribution and cannot be regarded as a production resource, but as they have been extensively studied for their pedological interest they are briefly discussed in the context of the Soil Map of the World, in Chapter 7.

Use of the map and explanatory text

Against the background of the topographic base the soil map shows the broad pattern of dominant soils, marked by different colours. Clusters of closely related colours have been used for soils which have similar characteristics so that major soil regions can be recognized.

More detailed information about each mapping unit can be derived from the soil association symbols. The composition of the soil associations is given in Chapter 5, in which they are listed alphabetically and numerically, together with areas, location, dominant vegetation and lithology. A table showing the composition of the soil associations is also given on the back of the maps.

The meaning of the classes for texture and topography which accompany the symbols of the mapping units is also explained on the soil map, as is the explanation of the overprints which indicate phases. These are further described in Chapter 3. The definitions of the soil units involved can be found in Volume I. The profile descriptions and analytical data in the Appendix illustrate and further clarify the soil definitions.

The geographical distribution of the soils is given in Chapter 5. For this purpose the region is divided into broad geomorphic provinces: the western plateau, interior lowlands and eastern uplands of Australia, the Papua New Guinea lowlands and mountains, the New Zealand northern volcanic plateau and central and southern regions, the complex high islands of the western Pacific margin, the oceanic high islands, and the low coral islands. The soils of these regions are discussed.

For information on the occurrence, land use, limitations, suitabilities and potentialities of the soil units, Chapter 6 should be consulted.

Those who are interested in the natural environment, as well as the nature, distribution and suitabilities of the soils, will find additional reading in Chapter 4. This chapter deals with climate, vegetation, physiography and lithology, and supplements the information given in Chapter 5.

2. ACKNOWLEDGEMENTS

The preparation of the Soil Map of Australasia and the Pacific could only be accomplished with the cooperation of government institutions and soil scientists who provided the basic material and took an active part in its assembly into maps and text.

Those who gave particular help to the project are listed below. Sincere appreciation is also expressed to all those it has not been possible to single out.

Contributors

OFFICIAL AGENCIES

Australia	Commonwealth Scientific and Industrial Research Organization (CSIRO): Division of Soils, Glen Osmond, South Australia; Division of Land Use Research, Canberra, A.C.T.; Woodland Ecology Unit, Canberra, A.C.T. Commonwealth Bureau of Meteorology, Melbourne, Victoria. University of New South Wales, Department of Geography, Kensington, N.S.W. Department of National Development: Bureau of Mineral Resources, Geology and Geophysics; and Division of National Mapping, Map Compilation Group, Canberra, A.C.T.
British Solomon Islands Protectorate	Department of Agriculture, Honiara. Land Resources Division, Ministry of Overseas Development, United Kingdom.
Fiji	Department of Agriculture, Forestry and Fisheries. University of the South Pacific, School of Natural Resources.
Hawaii (United States)	University of Hawaii, Department of Agronomy and Soil Science. U.S. Department of Agriculture, Soil Conservation Service.
New Caledonia, New Hebrides	Office de la recherche scientifique et technique outre-mer (ORSTOM), Noumea and Paris.
New Zealand	Department of Scientific and Industrial Research, Soil Bureau, Lower Hutt.
U.S. Trust Territory of the Pacific Islands	Office of the High Commissioner, Branch of Land Resources.

INDIVIDUAL CONTRIBUTORS

(This section lists those who contributed specifically to the project; many others have contributed through their published work and these are listed in the references)

Australia	Climate: D.O. Gaffney, W.J. Gibbs Vegetation: R. Milton Moore Geomorphology: D.Johnston, J.A. Mabbutt, K. Maynard Lithology: H.F.Doutch,W.D. Palfreyman, P.E. Simpson Soils: N.B. Billing, K.H. Northcote
British Solomon Islands Protectorate	J.R.F. Hansell, B.J. Leach. J.R.D. Wall
Fiji	S. Chandra, Thelma Richmond
Hawaii (United States)	L.D. Swindale
New Caledonia, New Hebrides	M. Latham, P. Quantin
Papua New Guinea	P. Bleeker
New Zealand	J.D. Cowie, R.B. Miller

U.S. Trust Territory of the Pacific Islands	N.P.Knott
Western Samoa	L.C. Blakemore, A.C.S. Wright

Preparation of the map

In close cooperation with the agencies and soil specialists listed above the map was compiled in 1972 by R.B. Miller in New Zealand. Sheet X1 (Australia) was prepared by K.H. Northcote and N.B. Billing, based on the *Atlas of Australian soils* by K.H. Northcote with G.G. Beckmann, E. Bettenay, H.M. Churchward, D.C. van Dijk, G.M. Dimmock, G.D. Hubble, R.F. Isbell, W.M. McArthur, G.G. Murtha, K.D. Nicolls, T.R. Paton, C.H. Thompson, A.A. Webb and M.J. Wright. Sheet X2 was prepared largely from published maps, but new maps using the Soil Map of the World legend were supplied from New Guinea by P. Bleeker, from the Solomon Islands by J.R.D. Wall and J.R.F. Hansell, from New Caledonia by M. Latham and from the New Hebrides by P. Quantin. New material on Fiji was supplied by Thelma Richmond and on Western Samoa by A.C.S. Wright and L.C. Blakemore. A first draft of the New Zealand map was prepared in FAO, Rome, in 1968 by R.B. Miller, with cooperation from H.S. Gibbs. The present map is revised and incorporates material from recent surveys of the South Island and Stewart Island. Contributions of unpublished data from many New Zealand pedologists are gratefully acknowledged.

No field correlation meetings were held specifically for the project, but consultations took place in Canberra in August 1971, and a number of the contributors were able to visit other territories during the course of the work. Liaison among the contributors and with FAO was maintained by correspondence. A visit to Western Samoa, Fiji and New Zealand by A.C.S. Wright in September 1971 enabled a number of soils in the Pacific to be correlated with similar soils in Central America and the Caribbean.

The responsibility for international correlation, preparation of the international legend and definition of soil units was entrusted to R. Dudal (FAO).

The drafting and colouring of the maps were carried out by D. Mazzei; the areas of the mapping units were measured by Miss M. Zanetti and Mrs. S. Allara (all FAO staff).

Grateful acknowledgement is made of the permission given by the American Geographical Society of New York to use its 1 : 5 000 000 World Map as a basis for the preparation of the Soil Map of the World.

Preparation of the explanatory text

The explanatory text was compiled in 1972 by R.B. Miller, who drew on a wide range of published papers and manuscripts and much material prepared specially for the project. The published sources are given in the references. Many people and agencies other than those listed above assisted. The following contributors were particularly helpful: The Commonwealth Bureau of Soil Science (Bibiography 1383 on soils and agriculture of the Pacific islands excluding Hawaii [1969-1933]); Miss Gina Douglas (Check List of Pacific Ocean Islands); Fiji National Archives (manuscripts and maps); Pacific Scientific Information Centre (bibliographic material); South Pacific Commission (publications); Prof. L.D. Swindale (University of Hawaii theses); the U.S. Army of the Pacific; the U.S. Department of Agriculture Soil Conservation Service, and the U.S. Geological Survey (survey publications).

Their help, and that of many others, is gratefully acknowledged.

Publication

Most of the publication costs of maps X1 and X2 and Volume X were met by the New Zealand Government as part of its Pacific Aid Programme. This was a further generous contribution from New Zealand to the Soil Map of the World.

3. THE MAP

Topographic base

The Soil Map of Australasia and the Pacific was prepared on the basis of the 1 : 5 000 000 topographic map series of the American Geographical Society of New York. The map is divided into two sheets, the first covering the whole of Australia and the second covering Papua New Guinea, New Zealand and the southwest Pacific ocean to about 180° longitude, and from (approximately) the equator to 48°S latitude. The Miller Oblated Stereographic Projection System is used, which allows all sheets to be fitted together continuously.

Map units

The map unit consists of a soil unit or of an association of soil units. The textural class is indicated for the dominant soil unit while a slope class reflects the topography in which the soil association occurs. The associations may be phased according to the presence of indurated layers or hard rock at shallow depth, stoniness, salinity and alkalinity. The soil units, classes and phases are defined in Volume I.

Each soil association is composed of dominant and subdominant soil units, the latter estimated to cover at least 20 percent of the delimited area. Important soil units which cover less than 20 percent of the area are added as inclusions.

The symbols of the mapping units show the soil unit, textural class and slope class as follows:

Soil units. The symbols used for the representation of the soil units are those given in the list on the back of the map. They are also listed in this section.

Textural classes. The textural classes, coarse, medium and fine, are shown by the symbols 1, 2 and 3 respectively.

Slope classes. The slope classes, level to gently undulating, rolling to hilly, and strongly dissected to mountainous, are indicated by the letters a, b and c respectively.

Cartographic representation

SYMBOLS

The soil associations have been noted on the map by the symbol representing the dominant soil unit, followed by a figure which refers to the descriptive legend on the back of the map in which the full composition of the association is outlined.

Example:	Lc79	Chromic Luvisols and Luvic Yermosols
	Ah13	Humic Acrisols and Chromic Vertisols

Associations in which Lithosols are dominant are marked by the Lithosol symbol I combined with the symbol for one or two associated soil units.

Example:	I-R	Lithosols and Regosols
	I-Po-Bd	Lithosols, Orthic Podzols and Dystric Cambisols

Where there are no associated soils or where the associated soils are not known, the symbol I alone is used.

If information on the texture of the surface layers (upper 30 cm) of the dominant soil is available the textural class figure follows the association figure, separated from it by a dash.

Example:	Hh1-3	Haplic Phaeozems, fine textured
	Ah13-2	Humic Acrisols, medium textured, and Chromic Vertisols

Where two groups of textures occur that cannot be delimited on the map, two figures may be used.

Example:	Lc79-1/2	Chromic Luvisols, coarse and medium textured, and Luvic Yermosols

Where information on relief is available the slope classes are indicated by a small letter, a, b or c, immediately following the textural notation.

Example:	Hh1-3a	Haplic Phaeozems, fine textured, level to gently undulating

SOIL UNITS FOR AUSTRALASIA

J	FLUVISOLS
Je	Eutric Fluvisols
Jc	Calcaric Fluvisols
Jd	Dystric Fluvisols
G	GLEYSOLS
Ge	Eutric Gleysols
Gd	Dystric Gleysols
Gm	Mollic Gleysols
Gh	Humic Gleysols
R	REGOSOLS
Re	Eutric Regosols
Rc	Calcaric Regosols
Rd	Dystric Regosols
I	LITHOSOLS
Q	ARENOSOLS
Qf	Ferralic Arenosols
Qc	Cambic Arenosols
Qa	Albic Arenosols
E	RENDZINAS
U	RANKERS
T	ANDOSOLS
To	Ochric Andosols
Tm	Mollic Andosols
Th	Humic Andosols
Tv	Vitric Andosols
V	VERTISOLS
Vp	Pellic Vertisols
Vc	Chromic Vertisols
Z	SOLONCHAKS
Zo	Orthic Solonchaks
Zt	Takyric Solonchaks
Zg	Gleyic Solonchaks
S	SOLONETZ
So	Orthic Solonetz
Sm	Mollic Solonetz
Sg	Gleyic Solonetz
Y	YERMOSOLS
Yh	Haplic Yermosols
Yl	Luvic Yermosols
X	XEROSOLS
Xh	Haplic Xerosols
Xk	Calcic Xerosols
K	KASTANOZEMS
Kh	Haplic Kastanozems
Kk	Calcic Kastanozems
H	PHAEOZEMS
Hh	Haplic Phaeozems
Hc	Calcaric Phaeozems
Hl	Luvic Phaeozems
Hg	Gleyic Phaeozems
B	CAMBISOLS
Bd	Dystric Cambisols
Be	Eutric Cambisols
Bh	Humic Cambisols
Bk	Calcic Cambisols
Bc	Chromic Cambisols
Bv	Vertic Cambisols
Bf	Ferralic Cambisols
L	LUVISOLS
Lo	Orthic Luvisols
Lc	Chromic Luvisols
Lk	Calcic Luvisols
Lf	Ferric Luvisols
La	Albic Luvisols
Lp	Plinthic Luvisols
Lg	Gleyic Luvisols
D	PODZOLUVISOLS
Dd	Dystric Podzoluvisols
P	PODZOLS
Po	Orthic Podzols
Ph	Humic Podzols
Pp	Placic Podzols
Pg	Gleyic Podzols
W	PLANOSOLS
We	Eutric Planosols
Wd	Dystric Planosols
Wh	Humic Planosols
Ws	Solodic Planosols
A	ACRISOLS
Ao	Orthic Acrisols
Af	Ferric Acrisols
Ah	Humic Acrisols
Ap	Plinthic Acrisols
Ag	Gleyic Acrisols
N	NITOSOLS
Ne	Eutric Nitosols
Nd	Dystric Nitosols
Nh	Humic Nitosols
F	FERRALSOLS
Fo	Orthic Ferralsols
Fx	Xanthic Ferralsols
Fr	Rhodic Ferralsols
Fh	Humic Ferralsols
Fa	Acric Ferralsols
Fp	Plinthic Ferralsols
O	HISTOSOLS
Oe	Eutric Histosols
Od	Dystric Histosols

In complex areas where two types of topography occur that cannot be delimited on the map two letters may be used.

Example: Re71-1ab Eutric Regosols, coarse textured, and Calcaric Regosols, level to rolling

If the information on texture is not available, then the small letter indicating the slope class will immediately follow the association symbol.

Example: Be102-c Eutric Cambisols and Rendzinas, steep

MAP COLOURS

The soil associations have been coloured according to the dominant soil unit. Each of the soil units used for the Soil Map of the World has been assigned a specific colour. The distinction between map units is shown by a symbol on the map.

The colour selection is made by clusters so that " soil regions " of genetically related soils will show up clearly.

If insufficient information is available to specify the dominant soil unit, the group of units as a whole is marked by the colour of the first unit mentioned in the list (e.g., the colour of the Haplic Yermosols to show Yermosols in general, the colour of the Orthic Podzols to show Podzols in general and the colour of the Ochric Andosols to show Andosols in general).

Associations dominated by Lithosols are shown by a striped pattern and by the colour of the associated soils. If no associated soils are recognized (because they occupy less than 20 percent of the area or because specific information is lacking), the colour of the Lithosol unit is applied uniformly over the hatched pattern.

PHASES

Eight phases are indicated on these sheets of the Soil Map of the World by overprints.

The *petric* and *petrocalcic* phases show the presence of indurated layers (concretionary and petrocalcic horizons respectively) within 100 cm of the surface.

The *stony* phase marks areas where the presence of gravels, stones, boulders or rock outcrops makes the use of mechanized agricultural equipment impraticable.

The *lithic* phase is used when continuous, coherent and hard rock occurs within 50 cm of the surface.

The *fragipan* phase or *duripan* phase marks soils in which the upper level of the fragipan or duripan occurs within 100 cm of the surface.

The *saline* phase shows that certain soils of the association (not necessarily the dominant ones) are affected by salt to the extent that they have a conductivity greater than 4 mmhos/cm in some part of the soil within 100 cm of the surface for some part of the year. The phase is intended to mark present or potential salinization.

The *sodic* phase is used for soils which have more than 6 percent saturation with sodium in some part of the soil within 100 cm of the surface.

It should be noted that Solonchaks are not shown as saline phases nor Solonetz as sodic phases since these soils are saline and sodic respectively by definition. It follows that to identify all areas with saline soils one should include saline phases plus Solonchaks, and areas with alkali soils should include sodic phases plus Solonetz.

Where more than one of these phases applies, only the one causing the strongest limitations for agricultural production is shown.

MISCELLANEOUS LAND UNITS

Miscellaneous land units are used to indicate salt flats, dunes and shifting sand, and glaciers and snow caps.

Where the extent of the land unit is large enough to be shown separately, the sign may be printed over a blank background. If the land unit occurs in combination with a soil association, the sign may be printed over the colour of the dominant soil.

Sources of information

In the map showing the sources of information of the Soil Map of Australasia (Figure 1) a distinction is made between the areas compiled from systematic soil surveys, from soil reconnaissance, and from general information combined with local field observations. Sources of information for the widely scattered land areas of map sheet X2 and other parts of the Pacific are indicated below.

About 6 percent of Australia has soil survey maps based on sufficient ground control to be placed in reliability class I. New Zealand and many of the Pacific islands can also be placed in class I. Inevitably there is variation in accuracy among these maps, depending on factors such as scale, methodology and purpose of preparation. The use of diverse methods of classification also makes correlation more difficult and directly reduces the reliability of the map. Further uncertainty is introduced by the influence on soil boundaries of differing concepts used in defining the units.

Approximately 68 percent of map sheet X1, in reliability class II, has been prepared from exploratory soil studies designed to give, in combination with basic information on the natural environment, an idea of the composition of the soil pattern. Advantage was taken of marked changes in the vegetational, geomorphological, lithological and climatic patterns in the preparation of the soil maps of certain areas where there was insufficient coverage by soil surveys.

The third class of reliability, covering 26 percent of the continent, refers to areas which are unexplored, or in which occasional soil studies have not supplied sufficient basic data for the compilation of more than a rough sketch of the soil pattern, even at the 1 : 5 000 000 scale. To understand the soil pattern of these regions, therefore, further studies need to be undertaken. Aerial photographs are seldom available. However, since these regions are mainly thinly populated and have poor accessibility, they usually occupy a low priority position for development. It may take a long time before the data necessary for improving the map become available. New aerial photographs and other information that could be provided by remote sensing from spacecraft and satellites may eventually be used.

In the preparation of the Soil Map of Australasia and the Pacific many documents were consulted. Although it is impossible to mention all of them, those covering substantial areas of the map or specifically prepared for the project are recorded here by the country of origin. Comment is also made on the reliability of the maps in the areas discussed.

AUSTRALIA

Soil survey work in Australia dates from the first decade of this century, although organized soil survey (by the Council of Scientific and Industrial Research) was not started until 1927. It has since been exten-

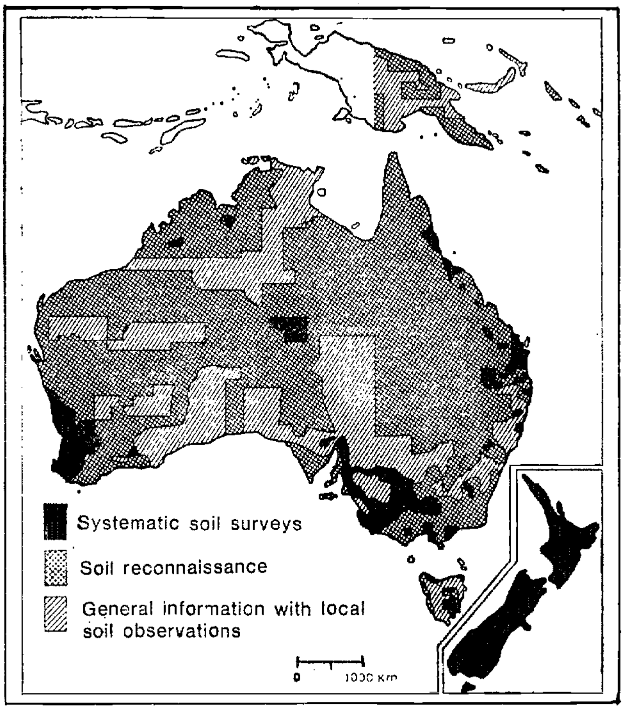

Figure 1. Sources of information

sively developed by State organizations and by the CSIRO Division of Soils and Division of Land Use Research. The history has been described by J.K. Taylor (1970), who gives 137 references. The first soil map of the continent, at a scale of 1 : 10 000 000, was prepared by Prescott in 1931 and revised in 1944. In 1963 Stephens produced a new map at 1 : 6 000 000, and Nicolls and Dimmock in 1965 produced a 1 : 1 800 000 map of Tasmania. These maps were based on the Great Soil Groups which were widely used internationally over this period. The soils were described by Stephens in *A manual of Australian soils*, first published in 1953 and revised in 1956 and 1962.

In 1968 Northcote completed the production of an entirely new *Atlas of Australian soils* (scale 1 : 2 000 000), in which soil units are classified on the basis of " profile form " as described in *A factual key for the recognition of Australian soils* (Northcote, 1960).

Also in 1968, Stace *et al.* produced *A handbook of Australian soils* to mark the Ninth International Congress of Soil Science in Adelaide that year. This was a volume of 435 pages with many comprehensive soil descriptions. The book contained a 1 : 10 000 000 map which shows both the Great Soil Groups and Northcote's profile forms.

The map of Australia for the Soil Map of the World was derived by K.H. Northcote and N.B. Billing from the 1 : 2 000 000 *Atlas of Australian soils* (Northcote *et al.*, 1968).

Papua New Guinea

The soil map of Papua New Guinea is derived from a map at 1 : 2 500 000 of the whole island (Haantjens *et al.*, 1967), and updated by recent field surveys in Papua New Guinea by the CSIRO Division of Land Use Research, Canberra (1964-74). These land system surveys have covered about half the territory, including most of the coastal regions (Brown, 1970). Numerous semidetailed surveys of small areas have also been carried out by the Land Utilization Section of the Department of Agriculture, Stock and Fisheries, Port Moresby.

New Zealand

According to tradition the Maoris distinguished different kinds of soil some 600 years ago. They selected fertile soils for their crops, drained wet soils, added sand to heavy soils, and fertilized with wood ash and fish waste. European surveyors reported on soils both before and after European settlement in 1840.

Chemical analyses of soils were carried out from the 1860s but it was not until 1903 that systematic soil surveys were advocated, and it was almost another 20 years before any were started. By 1930 soil surveys in the modern sense were being carried out by the Soil Survey, then attached to the Geological Survey of the Department of Scientific and Industrial Research. During the 1930s the value of soil surveys was established and since then the effort has steadily expanded, always with support from other disciplines. The history of soil science in New Zealand has been recorded by Pohlen (1957).

A national soil map (scale *c.* 1 : 2 000 000) was published with a genetic soil classification in 1948. A revised map at 1 : 3 200 000, with a modified legend by Taylor, Pohlen and Scott, appeared in 1959, and another at 1 : 1 000 000 followed in 1968 (New Zealand Soil Bureau, 1968*a*). Coverage at *c.* 1 : 250 000 was completed in the same year (New Zealand Soil Bureau, 1954, 1968*b*). These were all prepared by the Soil Bureau of the Department of Scientific and Industrial Research.

The map for the Soil Map of the World was derived mainly from the 1959 map, with checks against the 1 : 250 000 maps.

New Caledonia and New Hebrides

The soils of the French territories in the western Pacific and in eastern Polynesia have been studied extensively by soil scientists of ORSTOM centred in Noumea. A soil map of New Caledonia (scale 1 : 300 000) was published by Tercinier (1962), and also in 1962 C.G. Stephens prepared a soil correlation report (with a map at a scale of 1 : 2 400 000) for the Soil Map of the World project.

Tercinier (1962) reviewed previous work, including papers by both Barrau and Dugain published in the early 1950s and his own papers starting in 1953. Since 1962 Tercinier and others, including Latham, Quantin and Segalen, have published further papers about the soils of the region. Cohic (1959) has described the soils of the Chesterfield Islands.

Maps for the Soil Map of the World were prepared by M. Latham and P. Quantin, from Tercinier's maps, from unpublished reports and from recent field work in both New Caledonia and the New Hebrides.

SOLOMON ISLANDS

The most extensive soil studies in the Solomon Islands were made during the recent reconnaissance surveys by the Land Resources Division of the British Ministry of Overseas Development. Previous soil surveys had been made by the Department of Agriculture (Ballantyne, 1961; Leach, 1966, 1967, 1968) and other soil studies have been published by Ojala, 1947; Beatty *et al.*, 1962; Hutton, 1962; Clark and McLeod, 1966, 1967; Lee, 1969; Dalsgaard, 1970; Webb, 1972; and Wall and Hansell, 1973.

The 1 : 5 000 000 maps were prepared by J.R.F. Hansell and J.R.D. Wall in 1972.

FIJI

Systematic studies of Fijian soils began soon after the formation of the Agricultural Department in 1905, and in 1916 C.H. Wright wrote *Report on the soils of Fiji.* Blackie raised the possibility of a soil survey in 1937 but it was 1952 before this was started and another six years before it was finished. It was carried out by A.C.S. Wright and other pedologists of the New Zealand Soil Bureau and I.T. Twyford and assistants from the Fiji Department of Agriculture. The survey was reported by Twyford and Wright (1965) in a 570-page text volume and a volume of 23 maps, including a general soil map at 1 : 760 320 and soil and land classification maps at 1 : 126 720. The text briefly reviews earlier work; a more detailed history has been written by Twyford (1955).

Recent soil surveys by staff of the Department of Agriculture have been made, mainly on soils of alluvial plains such as those of the Sigatoka valley (Chandra, 1971). Other soil studies have been carried out by the School of Natural Resources of the University of the South Pacific.

The map for the Soil Map of the World was prepared from published data, from further material prepared by A.C.S. Wright and by Mrs. T. Richmond (University of the South Pacific), supplemented by observations made in Fiji by M.L. Leamy in 1973.

TONGA

Systematic studies of the soils of the islands of Tonga have been carried out mainly by New Zealand pedologists (Orbell, 1971; Gibbs, 1971, 1972; and M.L. Leamy and D.M. Leslie, personal communication), but the Tonga Department of Agriculture has also recorded contributions (Rosenberg, 1972*a*, 1972*b*). A number of studies of specialized interest have also been made (Cottrell-Dormer, 1944; Straatmans, 1954; Dr. H. Ikawa, personal communication). The 1 : 5 000 000 map was prepared from these sources, with additional information from members of the Tonga Department of Agriculture and from J. Hougland of the U.S. Peace Corps.

SAMOA

As in Fiji and Tonga, New Zealand scientists have made important studies of the soils of Samoa. Hamilton and Grange (1938), Seelye *et al.* (1938), and Grange (1949) were early contributors. Later Wright (1963) published a comprehensive survey of Western Samoa, with soil and land classification maps at a scale of 1 : 100 000 and soil maps of Upolu at a scale of 1 : 40 000, and Cowie (1974) made a detailed soil survey of the Asau Block, Savai'i. Wright's survey included a soil map of Tutuila, Eastern Samoa. More recently soil work has been undertaken by the FAO/UNDP Project SF1, by Alafua College, and by the Department of Soils and Agronomy of the University of Hawaii (Schroth, 1970, 1971).

The 1 : 5 000 000 map was prepared in consultation with A.C.S. Wright, using the sources noted above, with additional observations made in 1973 (M.L. Leamy, personal communication).

HAWAII

Soils and fertilizers (1954) in a bibliography of tropical soils 1930-53 lists numerous papers on Hawaiian soils, including a substantial handbook on Hawaiian soils by Moir *et al.* (1936). The first soil survey of Hawaii was that of Cline (1955), with a set of generalized maps of the main islands and detailed maps at scale 1 : 62 500. In the 644-page text Cline considered in detail the natural and cultural setting of Hawaiian soils, soils and their environment, agriculture and soils, and geography and soil characteristics.

Since 1955 the literature on Hawaiian soils has expanded rapidly. In 1972 the first part of a new soil survey was published (Foote *et al.*, 1972). All the main islands except Hawaii were surveyed at a scale of 1 : 24 000, the soils being classified in accordance with the U.S. Department of Agriculture *Soil taxonomy* (1975). General soil maps at a 1 : 253 440 scale were also included. These maps and associated publications and documents (Beinroth *et al.*, 1971; U.S. Department of Agriculture, 1972, 1973) were used to make the map for the Soil Map of the World.

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4. ENVIRONMENTAL CONDITIONS

In this chapter brief outlines are given of four aspects of the environment that are important in the development of soils. These are climate, vegetation, physiography and lithology.

These outlines indicate the location and nature of the major regions in which important variants of climate, vegetation, landscape and rock types occur. Clearly, only the broadest comparisons can be made in this space. For more detail, surveys of specific regions prepared by the appropriate government or other agencies should be consulted. Some are indicated in the references at the end of this chapter.

CLIMATE

A generalized climatic survey such as this provides only broad comparisons. For detailed material, reference should be made to climatic surveys of specific regions published by the appropriate meteorological services.

AUSTRALIA [1]

Australia extends from about latitude 10°S to latitude 44°S, but owing to moderating effects of the surrounding oceans and the absence of high extensive mountain masses it is less subject to extremes of climate than are regions of comparable size in other parts of the world. The average elevation of the land surface is low — about 270 m — while the maximum altitude is just above 2 200 m. Latitudinally Australian climate is generally more temperate than that of the other large land masses, although it ranges from tropical to alpine. Much of Australia is characterized by clear skies and low rainfall. These are typical features of subtropical regions and result from the general atmospheric circulation in which upward air motion occurs over the equatorial regions and descending motion over subtropical regions.

Climatic controls

In the winter half of the year (May-October) anticyclones pass from west to east across the interior of the continent. Northern Australia is under the influence of the dry southeast trade winds and southern Australia experiences westerly winds and frontal systems associated with the extensive depressions of the southern ocean. These depressions quite frequently develop secondary centres near the southeast coast and over the Tasman sea, resulting in the extension of cold rainy conditions, particularly on the highlands and in coastal areas.

In the summer half of the year (November-April) the subtropical high pressure systems are further south and move eastward across the southern coastal fringe so that easterly winds predominate over the continent. In southeast Australia rain depressions, usually associated with a pronounced southward intrusion of tropical air, develop toward the coast or over adjacent Tasman waters. Northern Australia is influenced by summer disturbances associated with the southward intrusion of moist northwest monsoonal air north of the intertropic convergence zone, resulting in a summer wet season in the north in contrast to the marked winter dry season in this region. Tropical cyclones develop over seas both to the northeast and the northwest of Australia in summer. Their frequency of occurrence and tracks vary greatly from season to season. On average, about three Coral sea cyclones per season affect the Queensland coast, and about two Indian ocean cyclones affect the northwest coast.

Rainfall

Analysis. To describe rainfall the median value is used. This is the value equalled or exceeded by half the occurrences and not exceeded by the other half. With annual rainfall the mean and median values are often approximately the same, but for shorter periods (three months or less) the mean can differ substantially from the median because of exceptional rain increasing the value of the mean.

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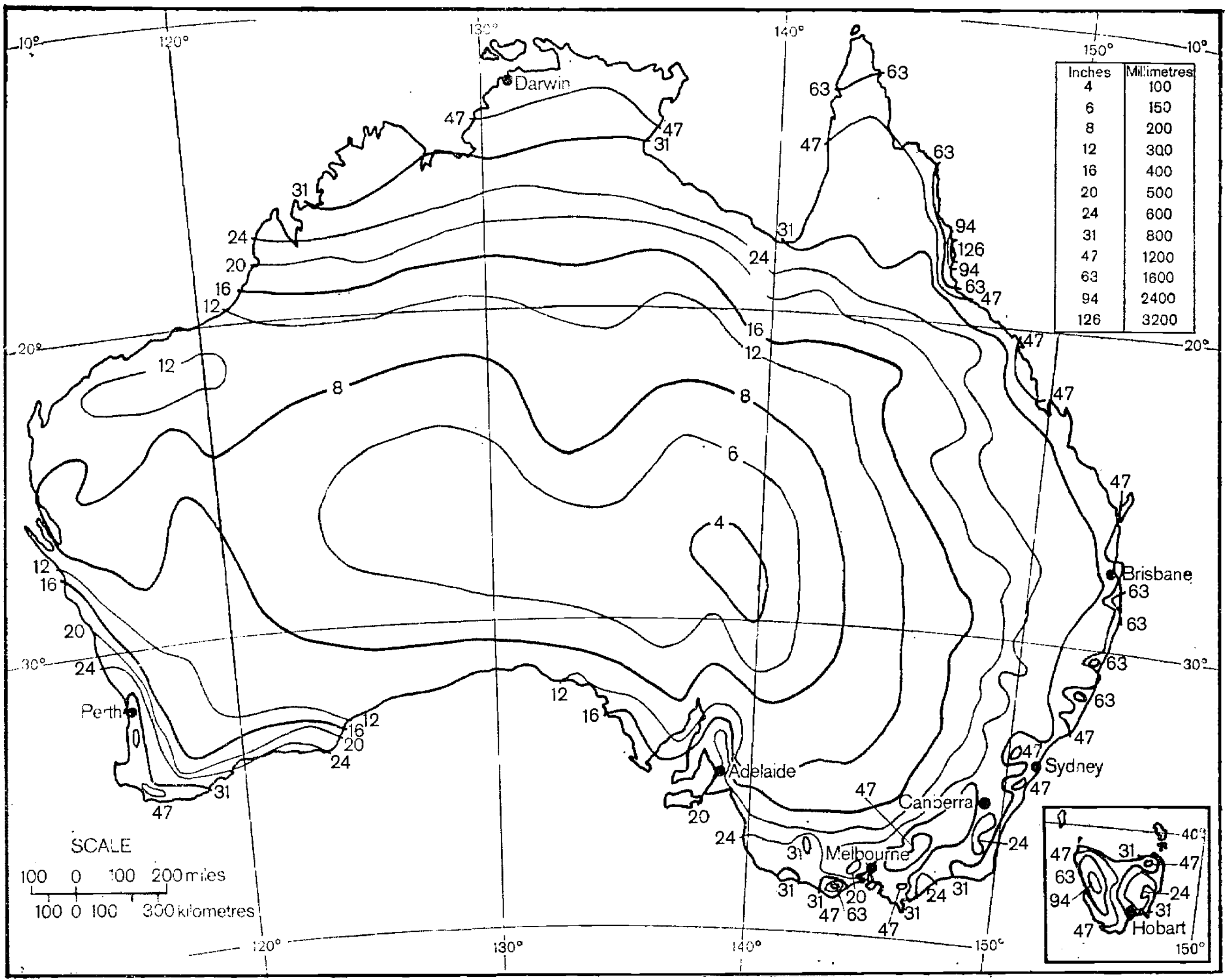
[1] The material for this section was supplied by W.J. Gibbs and D.O. Gaffney, Commonwealth Bureau of Meteorology, Melbourne, Victoria.



Inches	Millimetres
4	100
6	150
8	200
12	300
16	400
20	500
24	600
31	800
47	1200
63	1600
94	2400
126	3200

Figure 2. Annual 50 percentile rainfall in Australia (in inches)

Since the median usually gives a better indication of the rainfall most frequently occurring, it is preferable to describe monthly and even annual rainfall by the median value rather than by the mean.

To obtain some idea of the " spread " or variability of rainfall, the amount which is not exceeded in the driest 10 percent of years (the tenth percentile or first decile) and that exceeded in the wettest 10 percent of years (the ninetieth percentile or ninth decile) are now often used.

The decile concept is used to analyse rainfall in the Australian Bureau of Meteorology's periodic publications. A fuller treatment, with detailed statistics, is given by Gibbs and Maher (1967) and by the Bureau of Meteorology (1968).

Median annual rainfall. The median annual rainfall map (Figure 2) was prepared using long-term rainfall records. The area of lowest rainfall is east of Lake Eyre in South Australia, where the median is only 100 mm. Another very low rainfall area is in Western Australia in the Giles-Warburton range area, which has a median annual rainfall of about 150 mm. A vast region extending from the west coast near Shark bay across the interior of Western Australia and South Australia to southwest Queensland and northwest New South Wales has a median annual rainfall of less than 200 mm. This region is not normally exposed to moist air masses for extended periods and rain falls very infrequently, averaging only one or two days per month. However, in favourable synoptic situations, which infrequently occur over parts of the region, up to 250 mm of rain may be recorded within a few days with extensive flooding.

The region with the highest median annual rainfall is the east coast of Queensland between Cairns and Cardwell, where, at Tully, the median is 4 339 mm.

The mountainous region of western Tasmania also has a high annual rainfall, with 3 575 mm at Lake Margaret. In the mountainous areas of northeast Victoria and some parts of the east coast there are small areas with median annual rainfalls of 2 550 mm or more. In the Snowy mountains in New South Wales the highest median annual rainfall isohyet is 3 200 mm, and it is likely that small areas on the higher western slopes have a median annual rainfall of about 3 800 mm.

The distribution of median annual rainfall over Australia is shown in Table 1, which gives areas for isohyet intervals in Figure 2. It is evident that Australia is a dry continent, over 50 percent of its area having a median rainfall of less than 300 mm per year and nearly 30 percent having less than 200 mm.

Median seasonal rainfall. The main features of the seasonal rainfall distribution (Figure 3) are:

(*i*) marked wet summer and dry winter of northern Australia;

(*ii*) wet summer and low winter rainfall of southeast Queensland and northeast New South Wales;

(*iii*) uniform rainfall in southeast Australia;

(*iv*) marked wet winter and dry summer of southwest Western Australia and, to a lesser extent, of much of the remainder of southern Australia directly influenced by westerly circulations;

(*v*) arid area comprising about half of the continent, extending from the northwest coast across the interior and reaching the south coast at the head of the Great Australian Bight.

TABLE 1. - AREAS OF MEDIAN ANNUAL RAINFALL RANGES IN AUSTRALIA

Rainfall range	Area	
Millimetres	*Thousand sq km*	*Percent*
< 100	60	0.8
100- 150	860	11.2
150- 200	1 305	17.0
200- 300	1 725	22.4
300- 400	857	11.1
400- 500	689	8.9
500- 600	521	6.8
600- 800	782	10.2
800-1 200	616	8.0
1 200-1 600	228	3.0
1 600-2 400	39	0.5
> 2 400	5	0.1
Total	7 687	100.0

SOURCE: Planimeter estimation by Geographic Section, Australia Department of National Development, using the original drawing at 1: 5 000 000 for Figure 2.

KEY TO FIGURE 3 - SEASONAL RAINFALL ZONES

Seasonal maximum	Seasonal ratio	Median annual rainfall		Symbol h = high m = medium l = low
		Inches	Millimetres	
Summer-dominant (SS)	>3.0	>55	>1 300	SSh
		25–55	635–1 300	SSm
		15–25	380–635	SSl
Summer (S)	<3.0	>55	>1 300	Sh
	>1.3	25–55	635–1 300	Sm
		15–25	380–635	Sl
Uniform (U)	<1.3	>35	>890	Uh
		20–35	510–890	Um
		10–20	255–510	Ul
Winter-dominant (WW)	>3.0	>35	>890	WWh
		20–35	510–890	WWm
		10–20	255–510	WWl
Winter (W)	<3.0	>35	>890	Wh
	>1.3	20–35	510–890	Wm
		10–20	255–510	Wl
Arid (AZ)	>3.0	<15	<380	AZSS
		<10	<255	AZWW
	<3.0	<15	<380	AZS
	>1.3	<10	<255	AZW
	<1.3	<10	<255	AZU
	State	Altitude minima		Symbol
		Feet	Metres	
Alpine	N.S.W.	5 000	1 500	A
	Vic.	4 200	1 250	
	Tas.	3 500	1 050	

The seasonal rainfall distribution stems intrinsically from the seasonal atmospheric circulations which are the basic consideration in the development of a climatic classification for Australia. When the rainfall zones are studied in association with maps showing the distribution of elements such as temperature, frost, radiation and evaporation, a comprehensive climatic appraisal can be made to meet specified agricultural requirements. This approach is considered more meaningful for agricultural purposes in Australia than the integration of a series of climatic elements such as rainfall, temperature and evaporation into unified classifications. Many climatic classifications have limited agricultural application in Australia because they do not adequately treat seasonal circulations and do not take sufficient cognizance of the different climatic requirements of different plants.

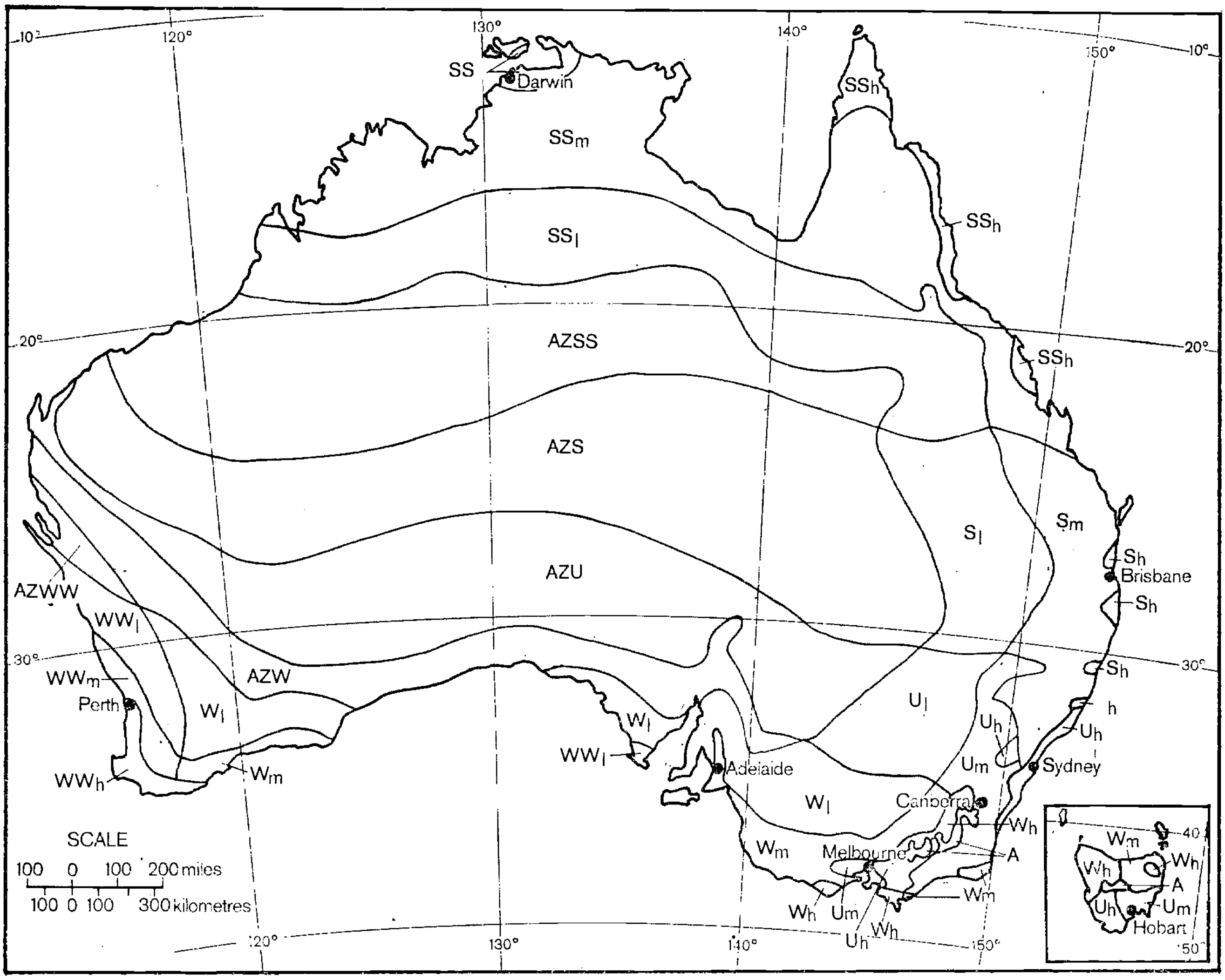


Figure 3. Seasonal rainfall zones in Australia

Variability of rainfall. An important characteristic of rainfall is its variability from year to year for any specified month, season, etc. An indication of the variability of annual rainfall is obtained from the magnitude of the difference between the first and ninth decile values. Monthly rainfall maps of Australia (scale 1 : 12 500 000) for 10, 50 and 90 percentile rainfall are given in Part 2 of the Bureau of Meteorology's *Review of Australia's water resources: monthly rainfall and evaporation.*

The regions of low variability, or most reliable rainfall, are the southwest of Western Australia, western Tasmania, and western and southern Victoria south of the Main Divide. The rainfall of these regions can be ranked among the most reliable in the world. Variability generally increases toward the dry centre.

The region of highest variability extends across the central part of the continent from southwest Queensland to the northwest coast of Western Australia. For example, at Carnarvon, Western Australia, annual rainfall totals have ranged from 67 to 644 mm (median, 214 mm) and at Birdsville, Queensland, from 33 to 542 mm (median, 114 mm).

High variability may also occur in the high rainfall areas; for example, at Tully, north Queensland, the annual rainfall has varied from 7 897 to 2 666 mm (median, 4 339 mm).

Rain day frequency. The highest frequency of rain days (days per year with rainfall of one point — 0.25 mm) occurs in Tasmania, southern Victoria, parts of the north Queensland coast, and the extreme southwest of Western Australia. In these areas the number of rain days is of the order of 150 per year. Western Tasmania has over 200 rain days per year. The annual frequency is less than 50 for most of the continent.

Rainfall intensity. Most of the very high 24-hour (09.00 hours to 09.00 hours) falls have occurred in the coastal strip of Queensland, where a tropical cyclone moving close to mountainous terrain provides ideal conditions for spectacular falls. The highest fall recorded in 24 hours, 910 mm, occurred at Crohamhurst.

Snow and hail. For varying periods from late autumn to early spring snow generally covers much of the ground on the Australian alps above a level of about 1 500 m. In Tasmania, also, the highlands are frequently covered above 1 000 m for extended periods in winter.

Hail, usually of a relatively small size, is most frequent in winter and spring along the southeast coastal region of the mainland, in Tasmania, and in the southwest of Western Australia. Summer storms, particularly on the highlands of eastern Australia, often produce hail of large size and of destructive intensity. Very large hailstones, capable of piercing light-gauge galvanized iron, are reported from time to time, and damage to fruit crops in southeast Australia from large hail is quite frequent.

Droughts. Since the early days of European settlement droughts have had a significant influence on the Australian economy. Foley (1957), in a review of records from the earliest years to 1955, found that in the preceding 100 years Australia had been subjected to at least seven major droughts affecting the greater part of the continent and several other droughts causing severe losses in smaller areas. A summary of droughts in Australia to 1968 appears in the Official Year Book of the Commonwealth of Australia for 1968.

Drought criteria may be derived from rainfall deciles. For defining the spatial distribution of drought from annual rainfall records, Gibbs and Maher (1967) used the first decile.

Table 2, compiled by Gibbs and Maher, shows the frequency distribution with which the annual rainfall was in the first decile range for the years 1885-1965.

These drought estimates are approximate, and are intended as a preliminary indication of drought risk and the manner in which drought areas cover the continent.

Flood rainfall. Widespread flood rainfall may occur anywhere in Australia but has a higher incidence in the north. It is most economically damaging along the shorter streams flowing from the Great Dividing range eastward to the seaboard of Queensland and New South Wales.

The Fitzroy and Burdekin river systems of Queensland are also subject to flood rains during the summer wet season. Much of the run-off due to heavy rain in north Queensland west of the Main Divide flows southward through the normally dry channels of the network of rivers draining into Lake Eyre. This widespread rain may cause extensive floods over a vast area, but it soon seeps away or evaporates, rarely reaching the lake in any quantity.

Flood rains occur in the Murray-Murrumbidgee system of New South Wales and Victoria and in the coastal streams of southern Victoria. In Tasmania, flooding of the north coast streams, particularly the South Esk, is common. In South Australia some flooding has occurred in the lower reaches of the Murray as a result of heavy prolonged rainfall in Queensland and southeast New South Wales. In

TABLE 2. - FREQUENCY WITH WHICH FIRST DECILE RANGE (DROUGHT) OCCURRED OVER GIVEN PERCENTAGES OF AUSTRALIAN STATES (1885-1965)

State	Percent of area										
	91–100	81–90	71–80	61–70	51–60	41–50	31–40	21–30	11–20	1–10	Nil
	Percent										
Western Australia	0	0	0	1	5	2	3	4	7	32	46
Northern Territory	0	1	1	0	2	6	2	3	6	14	63
South Australia	0	0	0	3	1	2	5	5	9	19	56
Queensland	0	0	0	2	1	4	2	10	7	25	49
New South Wales	0	1	1	1	4	2	2	2	2	32	53
Victoria	1	1	0	3	1	1	1	1	6	26	59
Tasmania	0	2	0	2	2	2	1	5	4	9	73
Australia	0	0	0	0	0	2	5	11	19	41	22

the north of Western Australia and the Northern Territory, flood rains occur in summer but are not of such economic importance as the flooding of the east coast streams of the continent.

Temperature

Average. Figure 4 shows the average annual isotherms over the continent. Average annual temperature varies from about 27°C in the north to 12°C in the south.

July is generally the month with the lowest average temperature. The month with the highest average temperature varies from February in Tasmania and southern Victoria to December in the northern part of the continent, and November in the Darwin-Derby area. The lateness of the month of highest average temperature in the extreme south of the continent is due mainly to the effect of the southern ocean, where the sea's surface temperature reaches its maximum in February. The slightly lower averages of summer in the north are due to increased cloudiness associated with the inflow of northwest air during the wet season.

Maxima. In January average maximum temperatures exceed 36°C over a vast area of the interior of the continent. The 24°C January maximum isotherm fringes the south coast.

In July a more regular latitudinal distribution of average maximum temperature is evident. The extreme north of the continent has average maxima about 30°C and in the extreme southeast they are about 12°C.

Minima. In January average minima north of the tropic are about 24°C, decreasing southward to about 12°C in Victoria and 9°C in Tasmania. Alpine re-

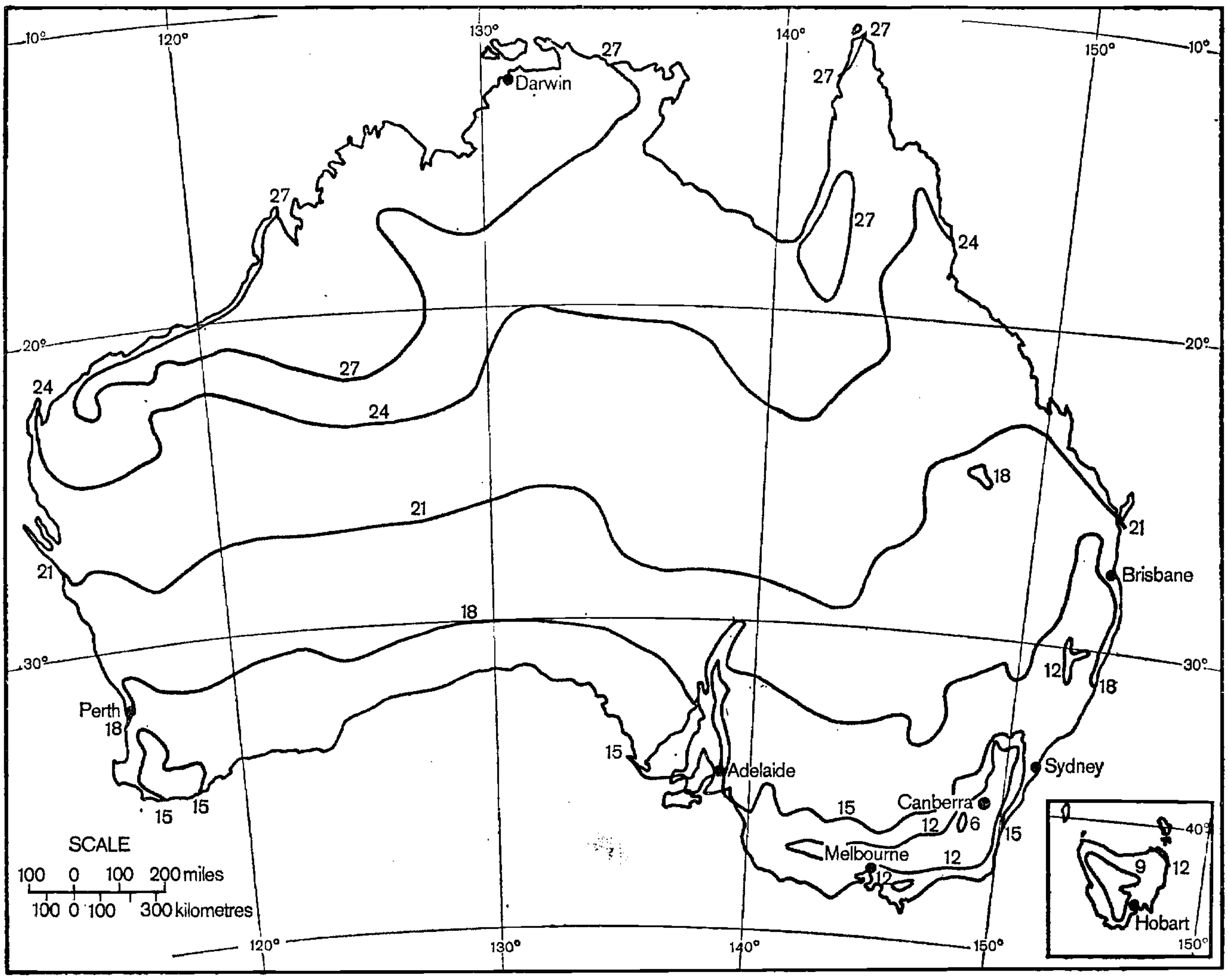


Figure 4. Average annual temperatures in Australia (°C)

gions in the southeast have average January minima below 6°C.

In July average minima are below 6°C in the areas south of the tropic and away from the coast. Highland areas in the south have July average minima below 0°C, and small alpine areas are below — 6°C.

Range. Generally the absolute range of temperature (i.e., the range from the highest maximum to the lowest minimum) is 21°C to 32°C in the inland areas and somewhat less on the coasts. The highest temperature recorded in Australia was 49°C at Cloncurry, Queensland, in January 1889, and the lowest was — 22°C at Charlotte Pass in the southern alps in July 1945 and again in August 1947.

Heat waves. Heat waves with a number of successive days higher than 38°C are relatively common in many parts of Australia. The frequency of such conditions increases inland, and periods of up to 20 days have been recorded over most settled areas. This figure increases in western Queensland and northwestern Western Australia to more than 60 days in places. The central part of the Northern Territory and the Marble Bar-Nullagine areas of Western Australia have recorded the most prolonged heat waves for the Australian region. The longest consecutive period of daily maxima greater than 38°C was 160 consecutive days recorded at Marble Bar during the summer of 1923-24.

Frosts. The parts of Australia which are most subject to frost are the eastern highlands from northeast Victoria to the western Darling downs in southern Queensland. Most stations in this region experience more than ten nights a month with readings of 0°C or under for three to five months of the year. On Tasmania's Central plateau similar conditions occur for three to six months of the year. Heavy frosts are comparatively infrequent in Western Australia, except in parts of the south and southwest.

Regions in which frosts may occur at any time of the year comprise most of Tasmania, large areas of the tablelands of New South Wales, much of inland Victoria, particularly the northeast, and a small part in the extreme southwest of Western Australia. Over most of the interior of the continent, and on the highlands of Queensland as far north as the Atherton plateau, frosts commence in April and end in September, but they are infrequent in these months. Minima below 0°C occur in most of the southern interior in June and July.

Climatic elements

The climatic elements — humidity, radiation, sunshine, evaporation and wind — are noted because of their significance for soils. Although treated separately, these elements are interrelated in their weathering properties.

Humidity. In northern Australia the highest values of average monthly relative humidity occur in the rainy summer season, the monthly average reaching a maximum about January (Darwin, 81 percent). In southern Australia highest values occur during the winter rainy season, the monthly average reaching a maximum about June (Melbourne, 83 percent).

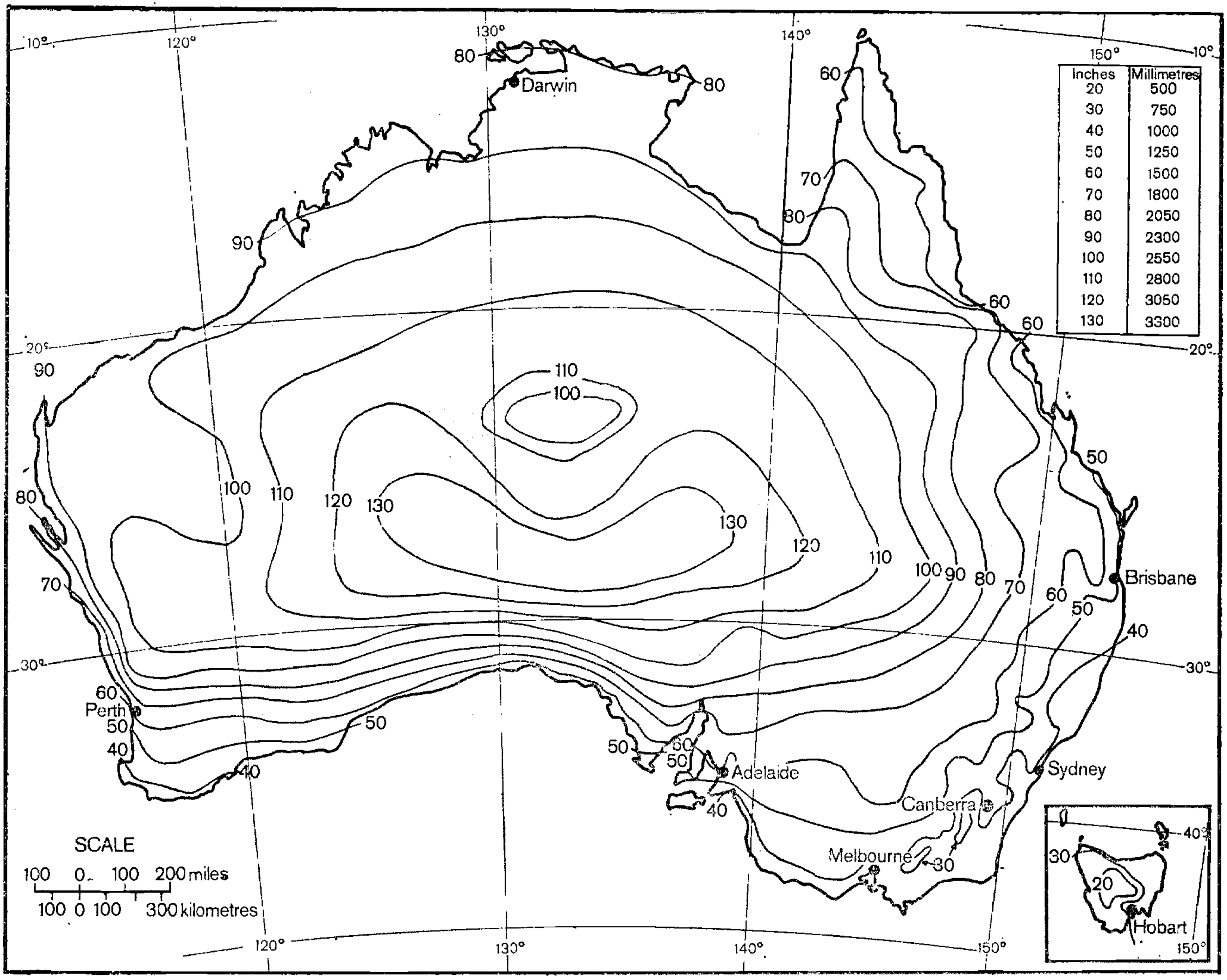
Radiation. Solar radiation is a significant parameter in the formation of soils. There are only a limited number of sites in Australia where global radiation (i.e., from sun and sky) is regularly recorded, but total solar radiation has been estimated using sunshine and cloud data. In July the average monthly global radiation varies more or less evenly from 450 cal cm^{-2} day^{-1} in Northern Territory to 125 in southern Tasmania. In January parts of inland New South Wales and Western Australia receive over 675 cal cm^{-2} day^{-1} and values decrease to the north to 450 and to the south to 500. The higher global radiation in the south in summer and in the north in winter is related to cloudiness.

Sunshine. Australia generally receives a large quantity of sunshine but seasonal cloud formations have a notable effect on its spatial and temporal distribution. Cloud cover reduces both incoming and outgoing radiation and thus affects sunshine, air temperature and other elements at the earth's surface.

Except for Tasmania and a narrow fringe bordering the southern, eastern and northern coasts, most of the continent receives more than 3 000 hours of sunshine each year, and in central Australia and the midwest coast of Western Australia totals in excess of 3 500 hours occur. The extreme south coast receives 2 000 to 2 500 hours annually and the east coast regions of New South Wales and Queensland receive 2 500 to 3 000 hours. A minimum of less than 1 750 hours occurs on the west coast and highlands of Tasmania.

Evaporation. Evaporation (Figure 5) is highly significant in Australia, as water conservation in dams and tanks is generally necessary. The water loss by evaporation from a free water surface varies from 500 mm over the highlands of Tasmania to 3 300 mm in the north and northwest of South Australia.

Over about 70 percent of the continent, including most inland districts, rainfall does not exceed evaporation loss from a free water surface in any month



Inches	Millimetres
20	500
30	750
40	1000
50	1250
60	1500
70	1800
80	2050
90	2300
100	2550
110	2800
120	3050
130	3300

Figure 5. Average annual evaporation in Australia (in inches)

of the year. The central and northwest areas of the continent experience evaporation far in excess of (greater than ten times) their rainfall. Evaporation from a free water surface provides a simple integration of several climatic elements, and is useful for comparison with more refined estimates of evaporation from soil surfaces and evapotranspiration.

Wind. Australia is influenced by two main prevailing wind systems:

southeast trade winds on the equatorial side of the midlatitude anticyclones;

westerlies south of the anticyclones.

It should be noted, however, that the continual growth, decay and motion of the pressure systems result in a wide diversity of wind-flow types.

PAPUA NEW GUINEA

Rainfall

Papua New Guinea lies within the heavy rainfall belt of the humid tropics, and well over half the area receives more than 2 500 mm of rainfall a year. The distribution is far from uniform, however, and ranges from less than 1 000 mm in a small area around Port Moresby on the south coast to over 6 000 mm at Gasmata on the south coast of New Britain. Two extensive belts receive over 5 000 mm a year. These are the south of New Britain and the southern face of the Central Cordillera, which intercept the southeasterly " trades " between May and August, and also receive heavy rainfall in the early part of the year from westerly moving vortical circulations separated by zones of convergence. These heavy rainfall systems do not, however, appear to

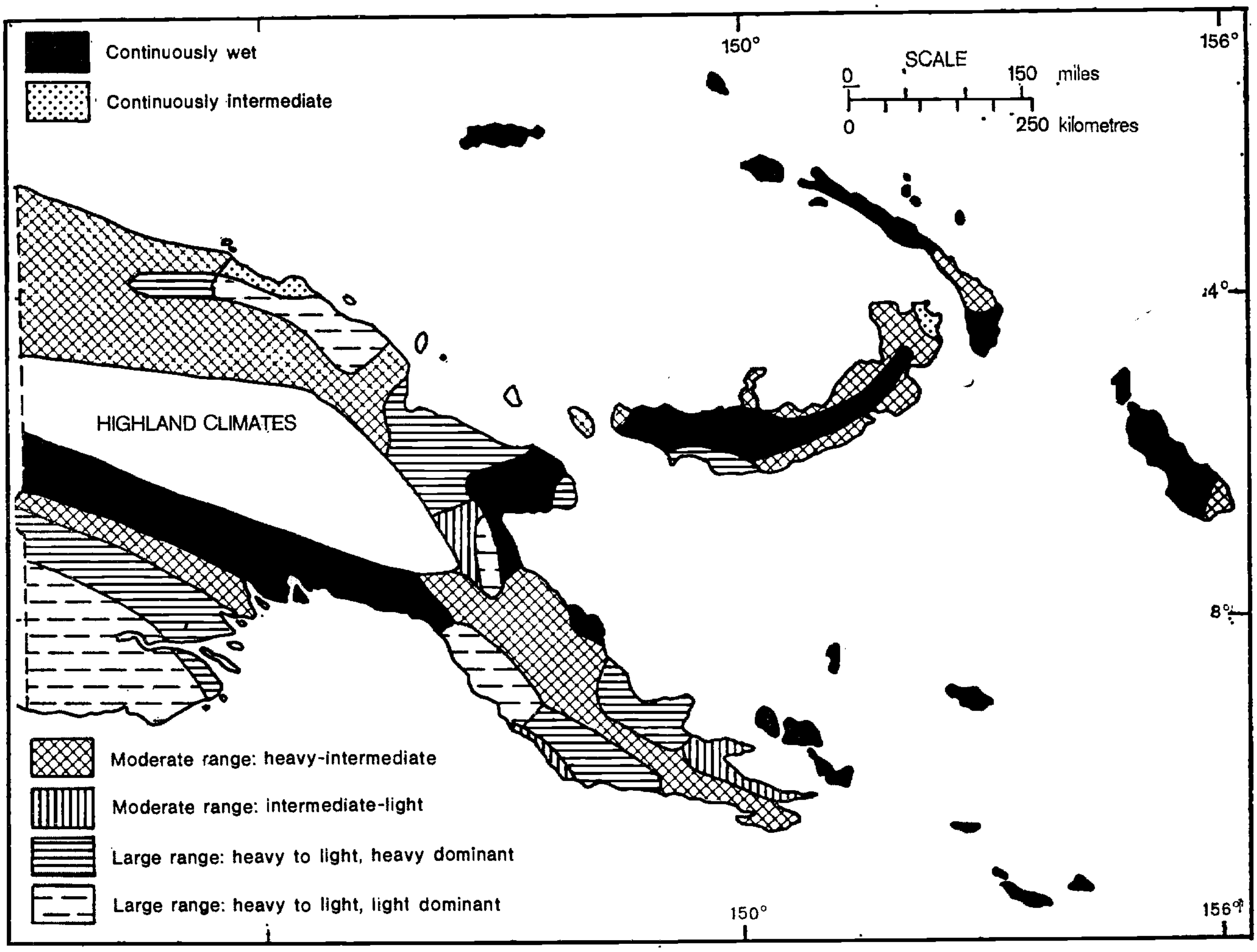


Figure 6. Rainfall regimes of Papua New Guinea

penetrate deeply into the central highlands (Hart, 1970).

Rainfall seasonality is expressed in Figure 6, which is based largely on Fitzpatrick *et al.* (1966). This shows that a large part of the area is non- or moderately seasonal, with wet or intermediate rainfall regimes. Areas of high seasonality, which may be important for growing crops requiring a dry period for harvesting, fall within the relatively dry zones of the south and the Markham valley.

Temperature

The temperature regime is typical of the humid tropics with moderately high temperatures and low seasonal variation. At higher altitudes, of course, temperatures are lower, as shown in Table 3.

NEW ZEALAND

New Zealand lies wholly within the temperate zone, between the high-pressure belt of the subtropics and the low-pressure trough of the southern ocean. A continuous eastward progression of anticyclones and depressions across the region gives rise to prevailing westerly winds high in moisture and moderate in temperature. The chain of high mountains standing in the path of the westerlies results in strong contrasts from west to east. In the west climates are moist and temperate, without a dry season, and in the Southern alps the precipitation may exceed 8 000 mm. To the east climates are drier, frequently with less than 1 000 mm rainfall, summers are warmer, föhn winds may cause high temperatures, and water deficiencies are common. In South Island intermontane basins some small areas occur with cold winters, hot summers and annual rainfalls below 500 mm.

Apart from such relatively small areas with extremes of rainfall and temperature, New Zealand is generally temperate, rainy, with warm summers but no marked dry season (Köppen Cfb). Animals can remain outdoors all year, even in the south.

For further information, publications of the New

Zealand Meteorological Service should be consulted. A useful review with a number of maps has been prepared by Robertson (1959). Cox (1968) has correlated climate with soil groups.

SOLOMON ISLANDS

The Solomon Islands extend from about 5-13° south of the equator and lie within 1 500-2 500 km of the Australian continent, but are not affected directly by the large, dry, permanent anticyclonic air masses which develop there. The islands lie in a comparatively low-pressure enclave where warm and humid equatorial air masses and relatively dry and cool subtropical air meet. This mobile, discontinuous and transient zone is known as the Inter-Tropical Convergence Zone (ITCZ).

The broader features of the climate can be explained in terms of the seasonal movements over it of two different kinds of air. From about March to November the islands experience steady southeasterly air flows, but during November there is likely to be unsettled weather as the ITCZ moves south, drawing after it the more stable northwesterly flows. These are nearing their limit of influence in the southerly Santa Cruz islands and in March and April weaken as the ITCZ returns and passes northward.

In some respects the climate of the Solomon Islands is uniform. Mean monthly temperatures and humidity at any given altitude vary little, and are easily exceeded by mean daily variations. Wind directions follow the basic pattern described above, the southeasterlies being the stronger and more constant with daytime surface speeds of 10-25 knots. These may be weakened or even reversed by the generation of local winds in the mountainous areas, with Honiara, for example, receiving cooling southerly night winds from the mountain range to the south.

TABLE 3. - TEMPERATURE IN RELATION TO ALTITUDE, PAPUA NEW GUINEA

	Mean annual temperature	
	Maximum	Minimum
Lowland .... (Madang, sea level)	30°C	23°C
Highland .... (Mount Hagen township, 1 750 m)	24°C	13°C
Alpine .... (Mount Wilhelm, 3 480 m)	12°C	4°C

Seasonal variation of mean temperature < 2°C.

Rainfall, by contrast, is outstandingly varied, and provides the main " weather " component. The areal distribution is affected markedly by the presence of mountain ranges lying athwart the direction of air flow. There appears to be an oceanic rainfall average of 2 500-3 500 mm. On Guadalcanal and San Cristóbal, however, there are marked rain shadows in the lee of mountains in different seasons, which in the former results in a mean annual rainfall at sea level of less than 2 000 mm on the northern plains and 4 000-6 000 mm on the southern coast only 40 km distant (Ash *et al.*, 1974). The effect of altitude on rainfall is illustrated in this same area, where an average of 8 500 mm is recorded at Chikora, 355 m high in the southern mountains. Islands aligned northwest-southwest, such as Santa Isabel, have little rain shadow effect but almost certainly have higher rainfall on the interior mountains.

An analysis of records on north Guadalcanal indicates that rain intensity and duration also vary widely, with brief falls of 1.5-6.0 mm/hr from cumulonimbus groups predominating and tending to occur mainly in the afternoon: maximum intensities exceeding 150 mm/hr rarely last longer than 30 min and 500-600 mm/day has been recorded but is unusual. Dry periods are equally important. In most areas rainless periods exceeding five days occur 5-10 times a year but rainless periods of 10 days or more are uncommon, except on the northern plains of Guadalcanal.

The islands also lie in that part of the south Pacific where cyclones are generated. They commonly develop along the ITCZ between January and April to the northeast of the Solomons, intensifying as they move southward. Associated turbulent winds sometimes exceed 100 knots in gusts and cause considerable damage, but these are usually confined to 20-km-wide belts. Rainfall at such times is also unusually prolonged and heavy.

NEW CALEDONIA

The climate of New Caledonia is oceanic, with southeast trade winds bringing rain most of the year. Much of the rain, carried in cyclonic depressions, is heavy and causes high stream flows. The usual seasonal distribution is moderate from April to August, low from September to November, and high from December to March. Mean annual rainfalls vary from less than 1 000 mm on the plains of the east coast " sous le vent " to more than 4 000 mm in the western mountains.

Temperatures are generally mild but summers, December to March, are hot. At Noumea, at sea level, mean monthly temperatures are 22°C in February, 19°C in August.

PACIFIC OCEAN

The Pacific is a vast expanse of open ocean covering one third of the surface of the earth, without a land mass of sufficient size to interrupt the planetary circulation of air and water masses.

In the eastern Pacific, air flows from two subtropical high-pressure systems (east of Hawaii in the north and of Easter Island in the south) toward the low-pressure belt along the thermal equator (the doldrums). These air flows are deflected by the earth's rotation into northeast and southeast winds (trade winds). In the central Pacific the doldrum belt may be narrow or absent and the trade winds may meet at an intertropical front characterized by atmospheric instabilities and heavy rainfalls. In the west the Asian and Australian land masses are subject to seasonal changes in temperature and hence atmospheric pressure that affect air movements out to 160°E longitude. The summer inflows and winter outflows of air are much stronger in the north, but the northwest monsoon of the Australian summer extends as far east as the Solomons.

Rainfall

The general pattern over the Pacific is of abundant, well-distributed rainfall. There is a tendency toward a southern summer wet season in the central Pacific (Brookfield and Hart, 1966), but toward the west this is much less pronounced. The broad pattern is interrupted on the larger high islands where aspect and seasonal shifts in the trade winds can give marked variations. For example, Suva, in Fiji, exposed to the prevailing easterlies, receives 3 107 mm of well-distributed rainfall annually, while on the leeward coast at Nandi the fall is 1 842 mm of which half falls from northerlies during the summer months January to March. In Hawaii, on the windward northeast slopes of the mountains falls may reach 10 000 mm, while in places on the leeward coasts they are less than 500 mm.

On the low islands, without orographic rainfall, variation from island to island and year to year may be considerable. Nurakita in the Ellice Islands, at latitude 11°S, for example, has a rainfall of 3 505 mm. This may be compared with the fall of 1 022 mm on Aranuka, in the adjacent Gilbert Islands, on the equator. Severe droughts lasting many months, with annual rainfalls as low as 200 mm, may occur on such equatorial islands in the Gilbert, Phoenix and Line groups. These, however, are exceptional, and most of the low islands have adequate falls well distributed through the year.

Temperature

Temperatures are characteristically high and uniform. Mean values lie between 21 and 29°C, and the annual range seldom exceeds 5°C. Diurnal variations, however, are usually between 5 and 10°C, being influenced on the larger islands by land and sea breezes.

Tropical cyclones

Most of the tropical areas are subject to hurricanes or typhoons, accompanied by destructive winds, torrential rains and high seas. In each cyclone, however, the belt causing damage is narrow and the benefits of the heavy rains over wide areas are substantial. Most islands have a mean annual maximum 24-hour rainfall of 200 mm or more, resulting from these tropical cyclones.

Sunshine

The tropical Pacific is sunny despite its high rainfall. This is because much of the rainfall is from thunderstorms which form and clear with relative rapidity.

Climatological-agricultural regions

This section indicates, very broadly, climatological-agricultural regions, using the classification system of Papadakis (1961, 1966) which has been used for other volumes of the Soil Map of the World.

The influence of climate on agriculture is such that it largely determines the type of cropping carried out in a region. Climate classifications, therefore, if they are to reflect the relationships that exist between climate and agriculture, must take into consideration factors significant for crops such as winter severity, duration of the frost-free season, potential evapotranspiration, and humid and dry seasons. The system of Papadakis does this, and the climatic regions he delineates coincide generally with regions recognized by agricultural geographers. The classification is very detailed, but only the higher categories are considered here.

The characteristics of the climate classification are given in Tables 4 to 8. Table 4 outlines the classification of climates of the Australasia-Pacific region at first decimal point level in terms of temperature and humidity regimes. Table 5 defines the temperature regimes of the climates, and Tables 6 and 7 the winter

TABLE 4. - CLIMATES OF THE AUSTRALASIA-PACIFIC REGION

Symbol	Classification [1]	Temperature and humidity regimes
1	TROPICAL	
1.1	Humid semihot equatorial	Eq; HU, Hu, MO (Humidity index > 1)
1.2	Humid semihot tropical	Tr; HU, Hu, MO (Humidity index > 1)
1.3	Dry semihot tropical	Eq, Tr; MO, Mo (Humidity index > 1)
1.4	Hot tropical	EQ, TR; MO, Mo
1.5	Semiarid tropical	EQ, Eq, TR, Tr; mo
1.6	Cool tropical	tr; HU, Hu, MO, Mo
1.7	Humid tierra templada	Tt, tt; HU, Hu, MO
1.9	Cool winter hot tropical	tR; HU, Hu, MO, Mo, mo
2	TIERRA FRIA (possibility of frost)	
2	Tierra fria	TF, Tf, tf, An, an, aP, ap, aF; HU, Hu, MO, Mo, mo
2.2	Low tierra fria	TF winter Ci Av; HU, Hu, MO, Mo, mo
3	DESERT	
3.1	Hot tropical desert	EQ, TR, tR; da, de, di, do
3.2	Hot subtropical desert	Ts, SU; da, de, di, do
3.4	Cool subtropical desert	Su, MA, Mm; da, de, di, do
4	SUBTROPICAL	
4.1	Humid subtropical	SU, Su; HU, Hu
4.2	Monsoon subtropical	SU, Su; MO, Mo, mo, dry spring
4.3	Hot semitropical	Ts summers G; mo, Mo, MO
4.4	Semihot semitropical	Ts summers g; HU, Hu, MO, Mo, mo
4.5	Semi-Mediterranean subtropical	SU, Su; MO, Mo nondry spring
5	PAMPEAN	
5.3	Subtropical pampean	SU, Su; St
5.4	Marine pampean	MA, Mm, TE, Ma; St
5.7	Semiarid peripampean	PA, TE, MA, Su, SU; si
5.9	Semiarid Patagonian	Pa, pa, ma, Te; mo, si, me
6	MEDITERRANEAN	
6.1	Subtropical Mediterranean	SU, Su; ME, Me
6.2	Marine Mediterranean	MA, Mm; ME, Me
6.5	Temperate Mediterranean	TE; ME, Me
6.8	Subtropical semiarid Mediterranean	SU, Su, Tr, tr, MA; me
7	MARINE	
7.1	Warm marine	MA, Mm; HU, Hu
7.2	Cool marine	Ma; HU, Hu
7.3	Cold marine	ma; HU, Hu
7.4	Polar marine	mp, mF; HU, Hu
7.5	Warm temperate	TE; HU, Hu
7.8	Humid Patagonian	Pa, pa; HU, Hu
10	POLAR	
10.3	Subglacial desert	Fr; any
10.4	Ice-cap	fr; any
10.5	Alpine	Al, al; any

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[1] "Mediterranean", "Pampean" and "Patagonian" refer to climatic types of the Mediterranean, the pampas and Patagonia, not to parts of Australasia locally known by these terms.

TABLE 5. - TEMPERATURE REGIMES OF CLIMATES OF THE AUSTRALASIA-PACIFIC REGION

Temperature regime [1]	Winter type	Summer type
EQ (Hot equatorial)	Ec	G
Eq (Semihot equatorial)	Ec	g
TR (Hot tropical)	Tp	G
Tr (Semihot tropical)	Tp	g
tR (Cool winter hot tropical)	tP	G, g
tr (Cool tropical)	tp	O, g
Tt (Tierra templada)	Tp, tP, tp	c
tt (Cool tierra templada)	tp	T
TF (Low tierra fría)	Ct or colder	g
Tf (Medium tierra fría)	Ci or colder	O, M
tf (High tierra fría)	Ci or colder	T, t
An (Low Andean)	Ti or milder	A
an (High Andean)	Ti or milder	a
aP (Andean taiga)	Ti or milder	P
ap (Andean tundra)	Ti or milder	p
aF (Andean subglacial desert)	Ti or milder	F
Ts (Semitropical)	Ct	G, g
SU (Hot subtropical)	Ci, Av	G
Su (Semihot subtropical)	Ci	g
Mm (Super-marine)	Ci	T
MA (Warm marine)	Ci	O, M
Ma (Cool marine)	av	T
ma (Cold marine)	av, Ti	P
mp (Marine tundra)	Ti	p
mF (Marine subglacial desert)	Ti	F
TE (Warm temperate)	av, Av	M
Te (Cool temperate)	ti, Ti	T
te (Cold temperate)	ti, Ti	t
PA (Pampean)	Av	M
Pa (Patagonian)	Tv, av, Av	t
pa (Cold Patagonian)	Ti, av	P
CO (Warm continental)	Av or colder	g, G
Co (Semiwarm continental)	Ti or colder	M, O
fr (Ice-cap)	ti or colder	f
Al (Low alpine)	Pr, ti, Ti	A
al (High alpine)	Pr, ti, Ti	a

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[1] "Andean", "Pampean" and "Patagonian" refer to climatic types of the Andes, the pampas and Patagonia, not to parts of Australasia locally known by these terms.

TABLE 6. - WINTER TYPES

Winter type	Average of the minimum of coldest month	Average of daily minima of coldest month	Average of daily maxima of coldest month	Notes
	° Centigrade			
Ec	> 7	> 18		Equatorial; sufficiently warm for equatorial crops, coconut, rubber, oil palm
Tp	> 7	13 to 18	> 21	Tropical; cooler than Ec and too cool for equatorial crops; too warm for wheat
tP	> 7	8 to 13	> 21	Medium tropical; wheat is marginal
tp	> 7		< 21	Cool tropical; frostless; winter is sufficiently cool for wheat
Ct	— 2.5 to 7	> 8	> 21	Citrus, tropical crops belt; not frostless; sufficiently mild for citrus; marginal for wheat
Ci	— 2.5 to 7		10 to 21	Citrus belt; sufficiently cool for wheat
Av	—10 to —2.5	> — 4	> 10	Avena, milder winter oats belt; not frostless; sufficiently mild for winter oats but not for citrus
av	> — 10		5 to 10	Colder winter oats belt
Tv	— 29 to — 10		> 5	Triticum, wheat-oat belt
Ti	> — 29		0—5	Milder winter wheat belt; too cold for winter oats
ti	> — 29		< 0	Cold winter wheat belt
Pr	< — 29		> — 17.8	Primavera, milder spring crops belt; too cold for winter wheat
pr	< — 29		< — 17.8	Cooler spring crop belt

TEMPERATURE LIMITS: The average of the minimum of the coldest month of 7°C is the limit of frostless climates, —2.5°C that of citrus, —10°C that of winter oats and —29°C that of winter wheat. The average of the daily minima of the coldest month of 18°C is the limit for equatorial crops, 13°C is the equatorial limit for wheat.

TABLE 7. - SUMMER TYPES

Summer type	Frost-free season [1]	Average of average daily maxima of *n* warmer months	Average of daily maxima of warmest month	Average of daily minima of warmest month	Average of average daily minima of two warmest months	Notes
	Months	° Centigrade				
G	Minimum > 5	> 25 (*n* = 6)	> 33.5			Gossypium, warm cotton; days very hot
g	Minimum > 5	> 25 (*n* = 6)	< 33.5	> 20		Cool cotton; still sufficiently long-warm for cotton; cannot be c
c	Minimum 12	> 21 (*n* = 6)	< 33.5	< 20		Coffee or cool night cotton; frostless; sufficiently warm for maize and cotton; nights cool enough for Arabica coffee
O	Minimum > 4	21 to 25 (*n* = 6)				Oryza; sufficiently long-warm for rice, not for cotton
M	Available > 4.5	> 21 (*n* = 6)				Maize; not warm enough for cotton; rice marginal; cannot be G, g, O or c
T	Available > 4.5	< 21 (*n* = 6) > 17 (*n* = 4)				Warm wheat; not warm enough for maize
t	Available 2.5 to 4.5	> 17 (*n* = 4)				Cold wheat
P	Available < 2.5	> 10 (*n* = 4)			> 3	Polar taiga; sufficiently warm for forest, not for wheat
p	Available < 2.5	> 6 (*n* = 2)				Polar tundra; sufficiently warm for tundra vegetation, not for forest or grassland; cannot be P
F		< 6 (*n* = 2)	> 0			Frigid, subglacial desert; too cold for tundra, not continuously ice-covered
f			< 0			Ice-cap
A	Available < 2.5 Average > 1	> 10 (*n* = 4)				Low alpine; more frosty than P; too frosty for forest, not for grassland; too cold for wheat; barley, potatoes, quinua, cañihua are grown
a	Average < 1	> 10 (*n* = 4)				High alpine; frosts in all months; sufficiently warm for grassland, not for forest

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[1] Curve of average monthly minima > 0° = Average, > 2° = Available, > 7° = Minimum.

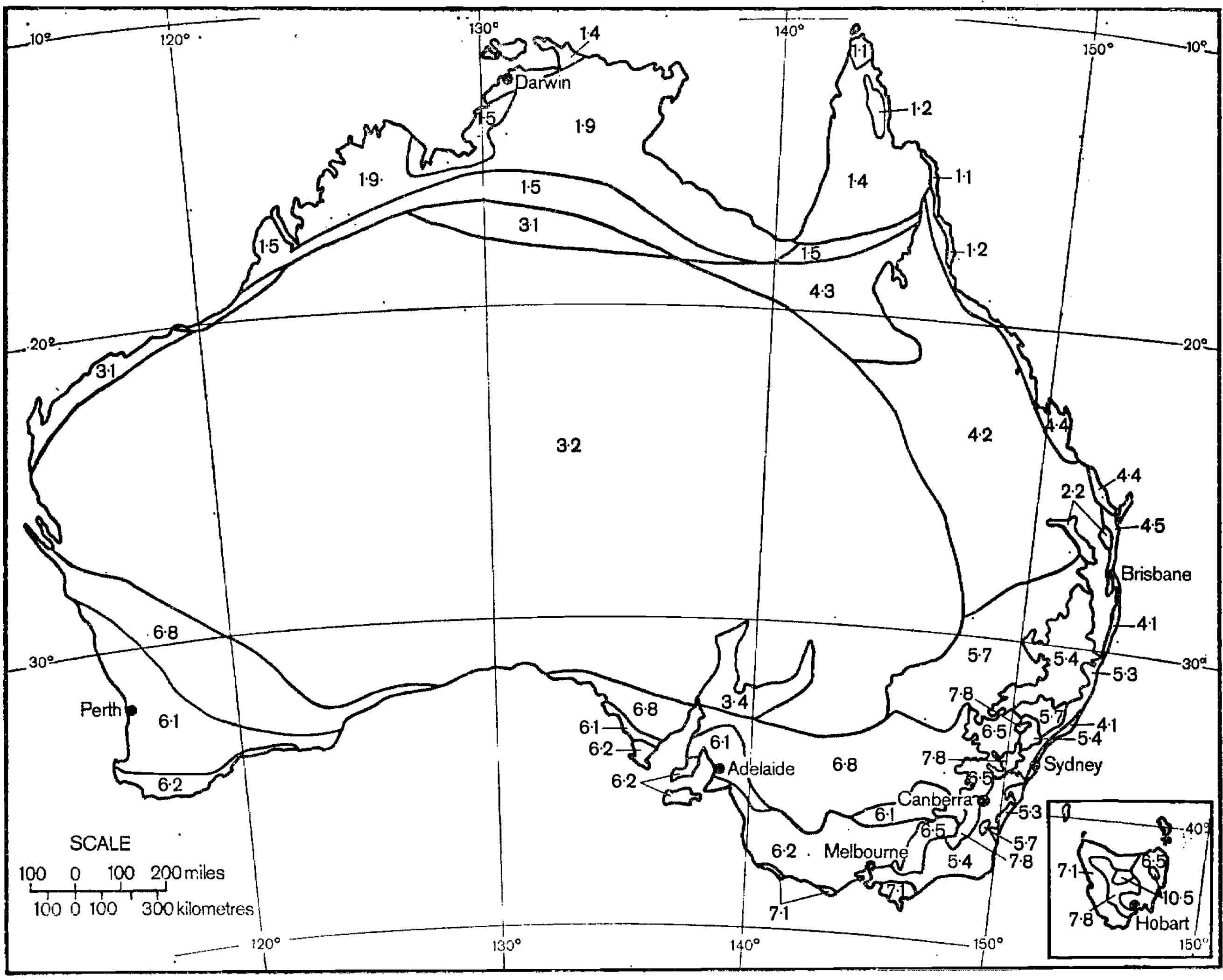

Figure 7. Climates of Australia

and summer types that together make up the temperature regimes. Table 8 defines the humidity regimes.

Indications are given in Tables 6 and 7 of some of the implications for crop ecology. For further details Papadakis (1952, 1961, 1966) should be consulted.

The table of soil associations in Chapter 5 shows the climates of the mapping units. They are therefore not further discussed.

The distribution of the broad climatic regions of Australia, Papua New Guinea and New Zealand is shown in Figures 7-9. Of the ten great groups of climate recognized in the classification, eight are found in the Australasia-Pacific region. These are:

1. TROPICAL

Tropical climates dominate the northern coast of Australia, the lowlands of Papua New Guinea, and most of the Pacific islands. All subgroups except dry frostless highlands are represented.

2. TIERRA FRIA

Nonfrostless tropical highlands are found in Papua New Guinea above 2 000 m, in small elevated areas near Brisbane, in Australia, and in the high mountains of Hawaii. In Papua New Guinea the highlands carry a substantial population and are important crop-producing areas.

3. DESERTIC

Desertic climates in the region are limited to Australia, but they cover enormous inland areas. Climate 3.2, hot subtropical desert, covers 55 percent of the continent. There are also relatively small

TABLE 8. - HUMIDITY REGIMES

Humid	No month is dry; HI > 1; Ln > 20% annual PE.
HU (Ever humid)	All months Humid.
Hu (Humid)	One or more months not Humid.
Mediterranean	Winter (June-August)[1] rainfall > summer (January-March)[1] rainfall; if summer is G, January is dry; not Humid; not Desertic; latitude > 20°.
ME (Moist Mediterranean)	Ln > 20% annual PE and/or HI > 0.88.
Me (Dry Mediterranean)	Ln > 20% annual PE; in one or more months with average daily maximum > 15°C available water > PE; HI 0.22 to 0.88.
me (Semiarid Mediterranean)	Too dry for Me.
Monsoon	HI (January-February) > HI (October-November); January and February should be humid or nondry if two winter months are humid or nondry respectively; not Humid; not Desertic.
MO (Moist monsoon)	Ln > 20% annual PE and/or HI > 0.88.
Mo (Dry monsoon)	Ln < 20% annual PE; HI 0.44 to 0.88.
mo (Semiarid monsoon)	HI < 0.44.
Steppe	Rainfall in three spring months > 0.5 PE; latitude > 20°; not Mediterranean; not Monsoon; not Humid; winter sufficiently cool for grassland (not Ct, Tp or Ec).
St (Steppe)	
Desert	All months with average daily maximum > 15°C are dry; HI < 0.22.
da (Absolute desert)	All months with average daily maxima > 15°C have humidity indices < 0.25; HI < 0.09.
de (Mediterranean desert)	Winter rainfall > summer rainfall; not da.
di (Isohygrous desert)	Not da; not de; not do.
do (Monsoon desert)	Humidity index for January-February > for October-November; not da.
si (Semiarid isohygrous)	Too dry for steppe; too humid for desert; not Mediterranean; not Monsoon.

NOTES: HI = annual humidity index; Ln = water surplus or leaching rainfall; PE = potential evapotranspiration.

[1] In the northern hemisphere seasons are reversed: summer is June-August and winter is January-March.

areas of hot tropical desert in the north and of cool subtropical desert in the south.

4. SUBTROPICAL

Subtropical climates are also limited to Australia. They are extensive in Queensland, covering most of the State south of the tropical area and east of the inland desertic area.

5. PAMPEAN

Pampean climates which have a steppe humidity regime, but differ from the northern hemisphere steppes in having mild winters, occur in both Australia and New Zealand. The largest areas are in northern New South Wales, where they extend from near the coast to the desertic boundary about half way across the State. They also occur in eastern coastal areas of southern New South Wales, Victoria and Tasmania. In New Zealand they are found in the South Island on the east coast and in semiarid inland basins.

6. MEDITERRANEAN

A number of Mediterranean subgroups occur in Australia. The most extensive is 6.8 (subtropical

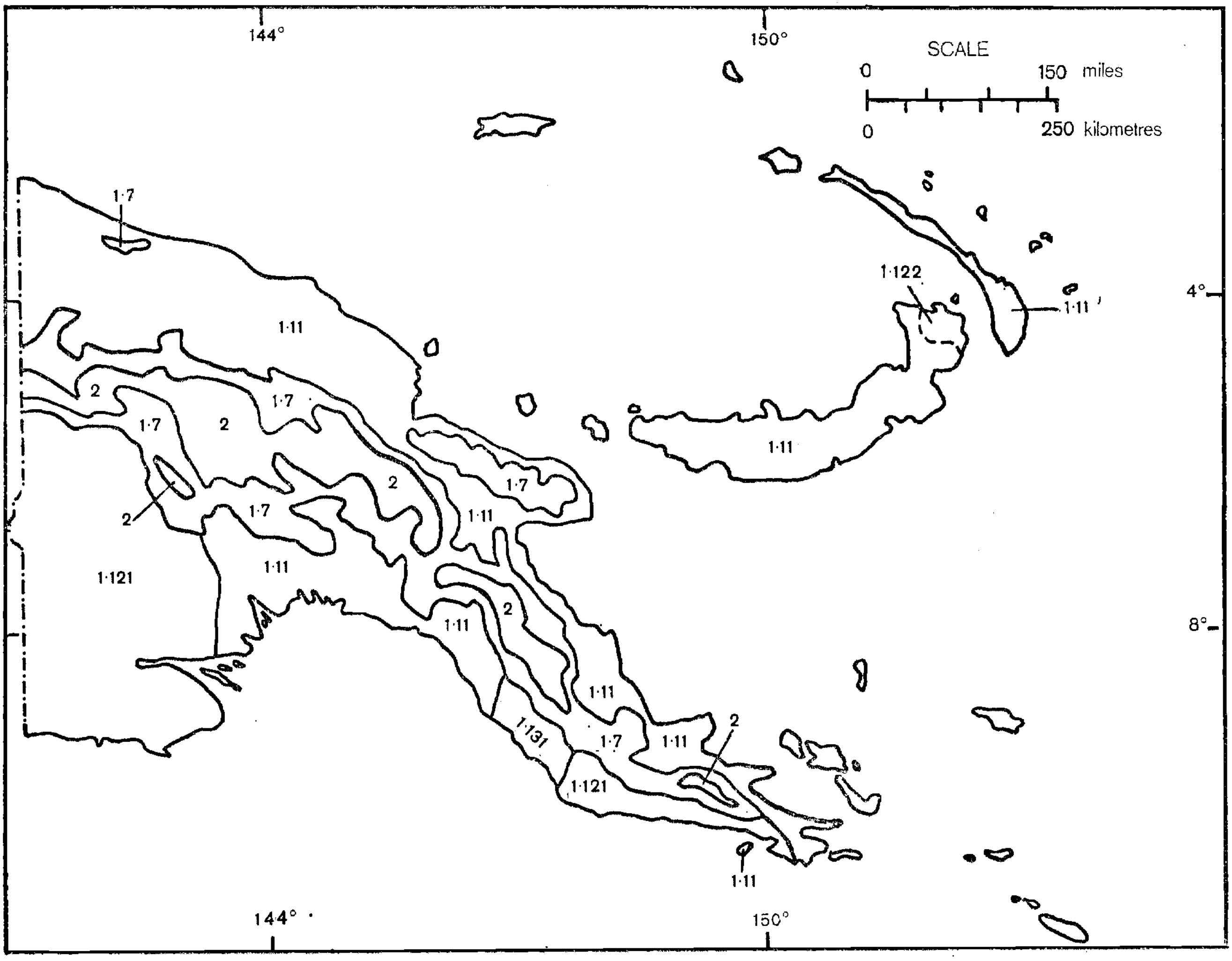

Figure 8. Climates of Papua New Guinea

semiarid) which is found particularly in southwest Australia and inland southern New South Wales. Subtropical and marine subgroups are found nearer the coast in the southwest, and in South Australia and Victoria. Other subgroups also occur.

7. MARINE

In Australia, marine climates are best expressed in Tasmania, although they are also found on the Victoria coast and in the southeastern mountains. They are the characteristic climates of New Zealand, occurring throughout the North Island and in the west and south of the South Island. The sub-Antarctic islands, such as Campbell and Macquarie, are found in the cold and polar marine subgroups.

10. POLAR

Polar climates are found in the Antarctic and in the midlatitude mountains. Subglacial desert occurs in the dry inland valleys and coasts of Antarctica, ice-cap is found over most of Antarctica, and alpine is found in the high mountains of New Zealand and Tasmania.

Climatic data for representative stations of the units shown in Figures 7-9 are given in Table 9. Information from some Pacific islands is also included.

VEGETATION

AUSTRALIA[1]

The accompanying vegetation map (Figure 10) is an adaption of that of Moore and Perry (Moore, 1970). The scale made it necessary to regroup some of the map units used in the original; the resultant

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[1] The material for this section was supplied by Dr. R.M. Moore, Woodland Ecology Unit, CSIRO, Canberra, A.C.T.

TABLE 9. – CLIMATIC CHARACTERISTICS OF STATIONS REPRESENTATIVE OF THE CLIMATIC REGIONS OF FIGURES 7, 8 AND 9

Map symbol	Climate classification	Station	Temperature, humidity regimes	Winter, summer types	Annual potential evapotranspiration	Annual rainfall[1]	Normal leaching rainfall[2]	Drought stress[3]	Humid season[4]	Dry season[4]
					Millimetres					
—	1.11	Hilo, Hawaii	Eq, HU	Ec, g	960	3 530	2 570	0	7–6	0
—	1.11	Mangareva, Tuamotu arch.	Eq, HU	Ec, g	860	2 230	1 370	0	8–7	0
—	1.11	Suva, Fiji	Eq, HU	Ec, g	790	2 990	2 200	0	8–7	0
—	1.12	Saipan, Mariana Is.	Eq, HU	Ec, g	780	2 100	1 320	0	5–3	0
1.1	1.13	Port Moresby, Papua	Eq, MO	Ec, g	920	980	320	260	12–4	9–10
—	1.21	Nukualofa, Tonga	Tr, HU	Tp, g	850	1 630	780	0	11–10	0
1.2	1.22	Noumea, New Caledonia	Tr, Hu	Tp, g	1 060	1 100	200	160	2–7	0
—	1.31	Honolulu, Hawaii	Eq, Mo	Ec, g	960	650	80	390	12–3	6–9
1.6	1.64	Raoul Is., Kermadec group	tr, HU	tp, M	590	1 440	850	0	12–11	0
2	2.12	Toowoomba, Queensland	TF, MO	Ci, c	970	930	40	80	12–3, 5–6	0
3.1	3.14	Wave Hill, N. Territory	TR, do	Tp, G	2 650	450	0	2 200	0	3–2
3.2	3.26	Alice Springs, N. Territory	SU, do	Ci, G	2 000	260	0	1 740	0	2–1
3.4	3.43	Port Augusta, S. Australia	su, de	Ci, c	1 410	250	0	1 160	0	7–6
4.1	4.14	Lismore, New South Wales	su, Hu	Ci, c	1 110	1 320	350	140	1–7	0
4.2	4.22	Roma, Queensland	SU, mo	Ci, G	1 800	520	0	1 280	0	2–1
4.3	4.31	Tambo, Queensland	Ts, mo	Ct, G	1 980	490	0	1 490	0	3–2
4.4	4.42	Rockhampton, Queensland	Ts, Mo	Ct, g	1 360	950	120	530	1–2	8–11
5.4	5.42	Melbourne, Victoria	MA, St	Ci, M	790	660	50	180	5–9	0
5.7	5.76	Bourke, New South Wales	SU, si	Ci, G	1 900	300	0	1 600	0	7–5
5.9	5.92	Alexandra, New Zealand	Pa, si	av, t	750	340	0	410	0	8–3
6.1	6.18	Perth, Western Australia	su, ME	Ci, c	1 050	930	480	600	5–9	12–4
6.2	6.23	Bendigo, Victoria	MA, Me	Ci, M	1 040	520	70	590	5–8	12–4
6.5	6.53	Canberra, A.C.T	TE, Me	Av, M	950	580	60	430	5–8	12–2
6.8	6.88	Eyre, Western Australia	su, me	Ci, c	870	300	0	570	0	9–4
7.1	7.12	Albany, Western Australia	MA, Hu	Ci, M	580	990	580	170	4–10	0
7.2	7.21	Dunedin, New Zealand	Ma, HU	av, T	480	940	460	0	3–2	0
7.3	7.31	Campbell Is., New Zealand	ma, HU	av, P	280	1 410	1 130	0	3–2	0
7.4	7.41	Macquarie Is., Australia	mp, HU	Av, p	100	1 060	960	0	12–11	0
7.5	7.51	Rotorua, New Zealand	TE, HU	Av, M	680	1 390	710	0	4–3	0
7.8	7.82	Hermitage, New Zealand	Pa, HU	av, P	580	4 400	3 820	0	3–2	0
10.3	10.3	Cape Adare, Antarctica	Fr	pr, F	80					
10.4	10.4	McMurdo Sound, Antarctica	fr	pr, f	90					
10.5	10.51	Miena, Tasmania	Al, HU	Ti, A	320	810	490	0	3–2	0

SOURCES: Data from Papadakis (1961). Base data from British Meteorological Office (1958).

[1] Annual rainfall = annual potential evapotranspiration × humidity index; in HU humidity regimes it was calculated from annual potential evapotranspiration plus leaching rainfall. – [2] Normal leaching rainfall = rainfall minus potential evapotranspiration during humid season. – [3] Drought stress = potential evapotranspiration minus rainfall during nonhumid season. – [4] Humid and dry seasons are shown as the months of the beginning and end of season; January = 1, December = 12.

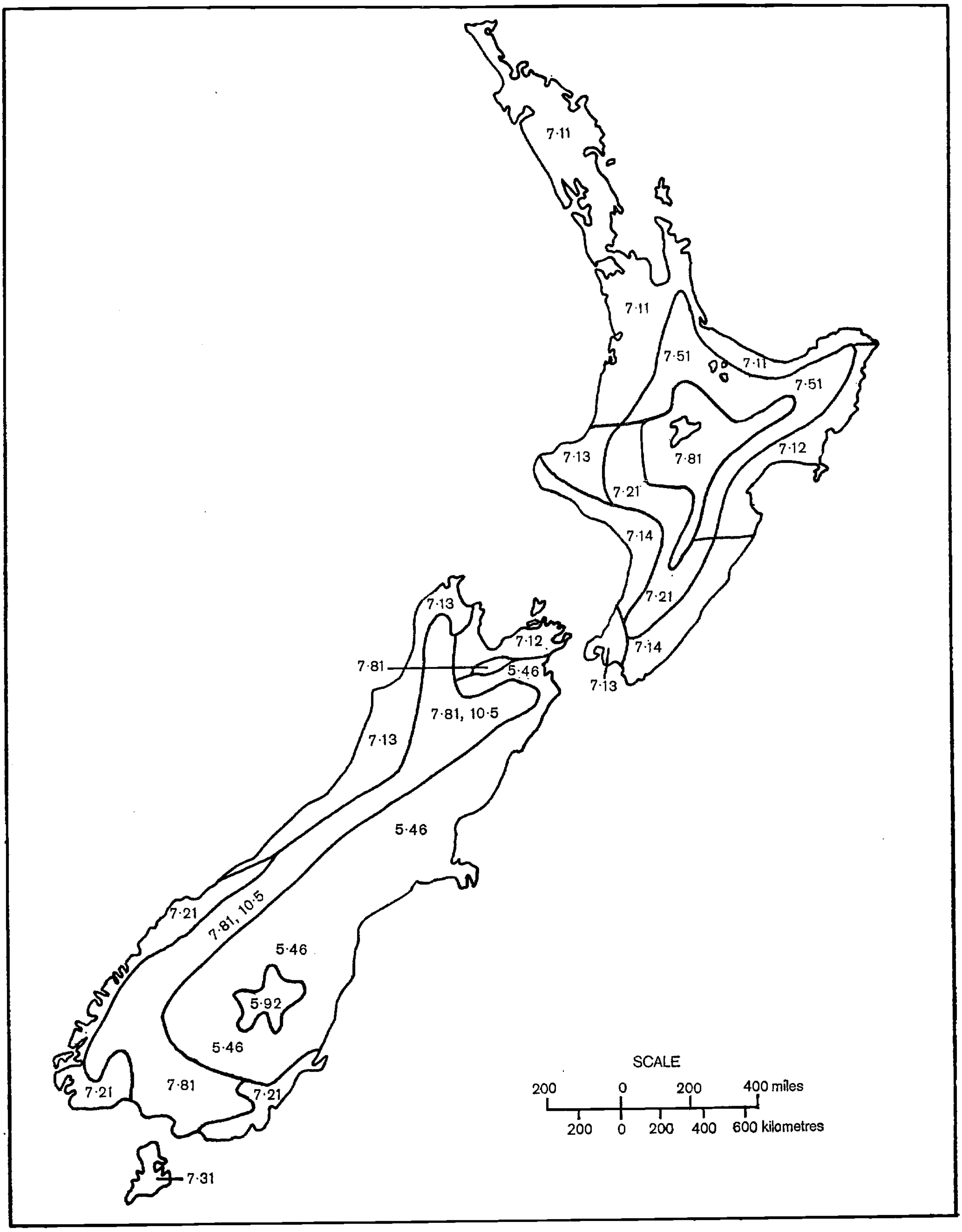

Figure 9. Climates of New Zealand

categories are consequently broad. Although boundaries are occasionally sharp, most formations intergrade floristically and structurally. Those shown on the map are approximate only and do not reflect the complex gradations and interdigitations that often exist between vegetation units. On tree form alone some parts of the areas shown as tropical woodlands might be designated open or grassy forests; they have been classified here as woodlands because of the density of the herbaceous layer.

The principal elements of the Australian flora are Indo-Malaysian, Autochthonian or Australian, and Antarctican (Gardner, 1944; Burbidge, 1960). Northeastern Australia is tropical and rich in Malaysian species and Australian endemics; the southwest is temperate and Mediterranean and has a high content of the Australian element. The floristic affinities of temperate rain forests and of alpine and subalpine areas are Antarctican. The extensive desert zone has a high proportion of woody species, and unlike many other arid regions has no large succulents.

A feature of the Australian element is the high degree of sclerophylly, particularly in the southwest. The families commonly represented in the Australian element are Epacridaceae, Myrtaceae, Proteaceae, and Papilionaceae. Species of *Eucalyptus* predominate in sclerophyll forests and woodlands on a wide range of soils in both tropical and temperate zones. A few species in the tropics are deciduous but most eucalypts are evergreen, even at the upper altitudinal limits of trees in alpine areas. Species of *Acacia* are even more numerous than *Eucalyptus*, and as well as characterizing arid shrublands and semiarid shrub woodlands are common understorey shrubs in woodlands and forests of the higher rainfall areas.

A feature of most *Eucalyptus* and other sclerophyllous species in Australia is their adaption to fire and capacity to regenerate vegetatively following mechanical injury. This has made land clearing difficult and expensive in most regions, particularly in the tropics. Fire promotes germination of most species of *Acacia* and the development of stem shoots from roots of others, notably brigalow (*Acacia harpophylla*).

1. *Heaths*

Tropical heaths (1a). The Wallum areas of coastal and subcoastal Queensland and northern New South Wales are a mosaic of eucalypt woodland, tree heath, and low heath dominated by *Banksia aemula* and other dwarf Proteaceae, Epacridaceae, Leguminosae and Myrtaceae. Grass trees (*Xanthorrhoea* spp.) are common in all but very wet situations. Tree heaths are characteristic of marshy situations; the common trees are tea trees, (*Melaleuca* spp.), swamp oaks (*Casuarina* spp.) and *Tristania suaveolens*. The trees of the eucalypt woodlands of the better drained rises are commonly *Eucalyptus racemosa*, *E. gummifera* and *E. acmenioides*. The soils of the heaths are Acrisols, Podzols, Dystric Planosols and Solonchaks, interspersed with Ferralsols and Solodic Planosols. From an agricultural viewpoint the soils are generally deficient in nitrogen, potassium, phosphorus, sulphur, molybdenum, copper, zinc and boron.

Temperate heaths (1b). In southeastern Australia temperate heaths frequently occur with both humid and dry temperate forests, and their species often form the understoreys of these forests. The soils are Dystric Regosols, Podzols, and Dystric and Solodic Planosols. Nutrient deficiencies include molybdenum, copper and zinc, as well as phosphorus, sulphur and nitrogen. The common eastern dry heath communities are *Banksia marginata-Leptospermum iuniperinum*, *Banksia ornata*, and *Leptospermum nitidum-Calythrix sullivanii.*

The vegetation of the wet heathlands of Victoria and Tasmania is dominated by sclerophyllous shrubs about 120 cm high. The principal species are the tea trees *Leptospermum scoparium*, *Melaleuca ericifolia*, *M. squarrosa* and *M. squamea*, the she-oaks *Casuarina stricta* and *C. bicuspidata*, and dwarf honeysuckle *Banksia marginata.* Grass trees (*Xanthorrhoea* spp.) are common in some areas. There are numerous species of lesser height.

Mallee heaths (1c). These are transitional communities between mallee (eucalypt shrublands) and dry heaths. The dominant species is a dwarf mallee eucalypt, *E. incrassata*, which in these communities seldom exceeds a height of 2 m. Other plants commonly present are *Banksia ornata* and species of the dry heaths. The soils are transitional between the Planosols and Solonetz of communities in which mallee eucalypts are associated with *Melaleuca uncinata*, and the deep Podzols and Regosols of the heaths. Mallee heath soils are deficient in nitrogen, copper, zinc, manganese and phosphorus, and sometimes potassium.

2. *Forests*

Humid tropical and subtropical forests (2a) in Australia are of two main types: rain forests of predominantly Indo-Malaysian species, and sclerophyll forests in which the dominant trees are eucalypts. Tropical rain forests are found in discontinuous belts along the eastern coast and adjacent highlands, mainly where soils are fertile and the annual rainfall is in excess of 1 250 mm. Common genera are

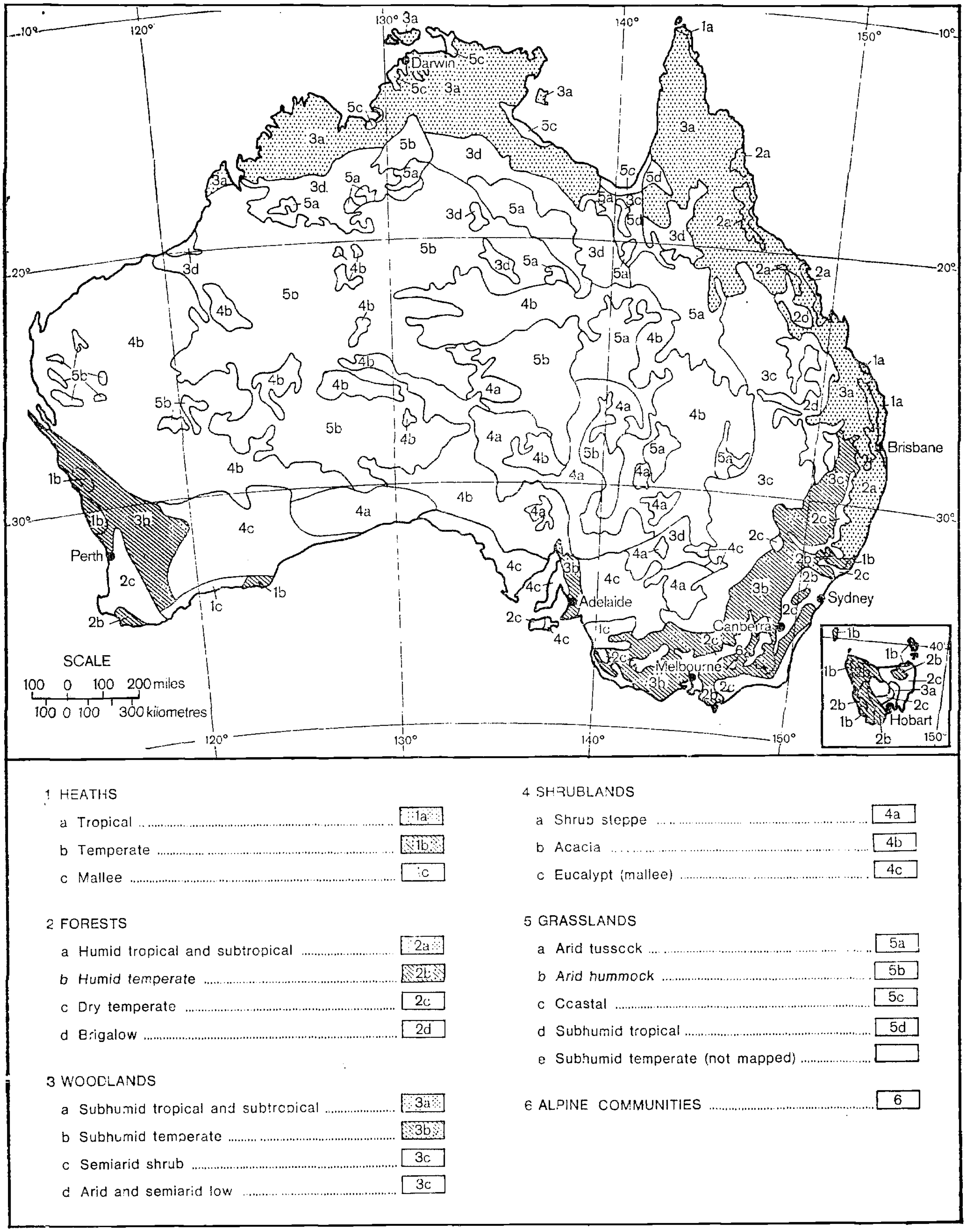

Figure 10. Vegetation of Australia

Agathis, *Cedrela*, *Araucaria*, *Cryptocarya*, *Dysoxylum*, *Cinnamomum*, *Eugenia*, *Tarrietia*, *Elaeocarpus* and *Ficus*.

Subtropical rain forests extend as far south as latitude 35°S and are less complex structurally than those of the tropics; *Araucaria cunninghamii* (hoop pine) and *A. bidwillii* (Bunya pine) are characteristic species.

The soils of the rain forests are Dystric Nitosols, Humic Acrisols, Ferralic Cambisols and Chromic Luvisols. In the tropics and subtropics rain forests have been cleared for timber, dairying, and the growing of sugarcane. Common soil nutrient deficiencies are nitrogen, phosphorus and molybdenum, and in some areas potassium.

Tropical and subtropical wet sclerophyll forests are dominated by species of *Eucalyptus*, commonly *E. pilularis*, *E. grandis*, *E. microcorys*, *E. racemosa*, *E. acmenioides*, and *E. gummifera*. Other species of frequent occurrence are *Tristania suaveolens*, *T. conferta*, *Syncarpia hillii* and *S. laurifolia*. Ground vegetation is commonly sparse but in more open forests the grasses *Themeda australis* and *Imperata cylindrica* are present in varying degrees of abundance. The soils, commonly various Luvisols, require the addition of nitrogen, phosphorus, molybdenum, and sometimes potassium, when used agriculturally.

Humid temperate forests (2b). The dominant species of temperate rain forests in northern and western Tasmania are myrtle beech (*Nothofagus cunninghamii*) on fertile soils derived from basalt, and sassafras (*Atherosperma moschatum*) on poorer soils. In northern New South Wales and Victoria rain forests have elements of subtropical vine forests and contain many species. *Eugenia smithii* and *Acacia melano-xylon* are often the dominant trees, and lianes are common. The soils are relatively fertile, commonly Dystric Nitosols derived from Tertiary basalts. Temperate rain forests are used for timber and, when cleared, for sowing to pasture for dairy cattle. The most widespread nutrient deficiency is molybdenum.

Temperate wet sclerophyll forests occur on less fertile soils and at lower rainfalls than rain forests. The dominant species in most of the wet sclerophyll forests of Tasmania and Victoria is mountain ash (*Eucalyptus regnans*). At elevations above 900 m this species is replaced by alpine ash (*E. delegatensis*). Tasmania blue gum (*E. globulus*) is also common in southeastern Tasmania. Usually there is a dense understorey of small trees and shrubs and ferns are abundant.

In New South Wales the coastal wet sclerophyll forests are subtropical or mixed subtropical-temperate. In the humid temperate forests of the tablelands of southeastern New South Wales and eastern Victoria the principal species are *Eucalyptus fastigata*, *E. viminalis*, *E. cypellocarpa* and *E. robertsoni*.

The only wet sclerophyll forest in Western Australia is in the extreme southwest corner of the State and is dominated by karri (*Eucalyptus diversicolor*), *E. jacksoni*, *E. guilfoylei* and *E. calophylla*. Prominent understorey species are *Casuarina decussata*, *Agonis flexuosa* and *Banksia* spp.

The soils of temperate wet sclerophyll forests are various Luvisols, Acrisols and Podzols. All are strongly acidic and low in phosphorus, most are deficient in molybdenum and sulphur, and some in potassium and copper.

Dry temperate forests (2c). Dry sclerophyll forests occupy the slopes of ranges in northeastern Tasmania and from Queensland to the southwest of Western Australia. They commonly occur on the tops and upper slopes of hills throughout the temperate woodland zone of southeastern Australia. Their distribution appears to be determined as much by the low nutrient status of soils as by rainfall, as they occur along the eastern and southeastern coasts, and on Kangaroo Island.

The principal species of coastal dry temperate forests in New South Wales are *Eucalyptus racemosa*, *E. piperita* and *E. gummifera*. Inland, in the woodland zone, the *E. rossii-E. macrorhyncha* dry temperate forest is widespread in New South Wales and Victoria. Other species commonly present are *E. radiata*, *E. elaeophora* and *E. polyanthemos*. There is usually an understorey of sclerophyllous shrubs belonging to Proteaceae, Leguminosae and Epacridaceae. Further inland and in still drier areas the dominant eucalypts are *E. sideroxylon* and *E. dealbata*. In Victoria and South Australia *E. baxteri* is common in dry temperate forests. It is the only tree in many forests, but in others it is associated with *E. obliqua*. Common understorey species are *Pteridium esculentum*, *Xanthorrhoea australis*, *Hibbertia stricta* and *Acacia* spp. On Ferric Luvisols in South Australia a dwarf form of *E. baxteri* occurs in a heath community which toward the dried limits of its range merges with eucalypt shrublands (mallee).

The principal dry temperate forest in Western Australia is jarrah (*E. marginata*). Associated species are *E. patens* and *E. calophylla*. The common understorey genera are *Persoonia*, *Banksia*, *Agonis* and *Casuarina*.

The principal soils of dry temperate forests are Luvisols, Planosols, Solonetz, and Regosols. In the wetter areas of their range dry temperate forests are used for pome and stone fruit production. In other areas they provide rough grazing for sheep and cattle. Correction of soil nutrient deficiencies of sulphur, phosphorus and molybdenum has enabled large zones to be converted to pastures based on subterranean clover (*Trifolium subterraneum*).

Brigalow forest (2d). This forest occupies much of the area between the 760-mm and 500-mm annual isohyets and latitudes 20 and 29°S. The characteristic species is a leguminous tree, brigalow (*Acacia harpophylla*). Brigalow may be associated with wilga (*Geijera parviflora*), poplar box (*E. populnea*), napunyah (*E. thozetiana*), sandalwood (*Eromophila mitchellii*) and belah (*Casuarina cristata*). Brigalow soils are mainly Chromic Vertisols and commonly exhibit gilgai microrelief. There are no nutrient deficiences limiting cereal and pasture production immediately after felling the forest, but a major problem is the regrowth of the brigalow tree.

3. *Woodlands*

Subhumid, tropical and subtropical woodlands (3a). This eucalypt subformation extends in a broad crescent from the northwest of Western Australia to Cape York peninsula in northern Queensland. The *Eucalyptus tetrodonta-E. miniata* community, a tall open woodland with a discontinuous shrub layer, is extensive in this area. At its southern and drier limits the community intergrades with semiarid shrub woodlands and semiarid low woodlands. Species frequently associated with the two dominant eucalypts west of longitude 140°E include *E. polycarpa, E. bleeseri, E. tectifera* and *E. ferruginea*. Common perennial grasses are *Themeda australis, Chrysopogon fallax, Sorghum plumosum* and *Heteropogon triticeus*. Important annual grasses are the tall sorghums (> 3.5 m), *Sorghum intrans, S. stipoideum, S. australiense* and *Brachyachne convergens*. The most widespread soils are shallow sandy Lithosols and Regosols.

The plant communities of Cape York peninsula have been described by Pedley and Isbell (1971).

East of longitude 140°E, and extending in a discontinuous belt to the latitude of Sydney, there are woodlands in which one or both of the narrow-leaved ironbarks, *E. crebra* and *E. drepanophylla*, are prominent. Other eucalypts present in tropical and subtropical areas are *E. dichromophloia, E. tereticornis, E. intermedia, E. exserta, E. papuana, E. alba* and *E. tessellaris*. The density of the shrub layer varies but where present the common constituents are *Alphitonia excelsa, Petalostigma pubescens, Lysicarpus angustifolius* and *Acacia* spp. *Heteropogon contortus, Themeda australis* and *Bothriochloa decipiens* are prominent in the ground layer. The soils are principally Solodic Planosols and Solonetz, and for agricultural purposes are deficient in phosphorus and molybdenum. Tropical and subtropical woodlands are used almost solely for beef cattle production.

Subhumid temperate woodlands (3b). Temperate woodlands are the most productive of the vegetation formations for agricultural and pastoral enterprises, and occupy large areas in South Australia and Western Australia. In New South Wales *Eucalyptus melliodora-E. blakelyi* and *E. albens* communities occur on acid Solodic Planosols and Solonetz soils in areas receiving between 480 and 710 mm of rain annually. In the more northern part of the range *E. tereticornis* becomes dominant. Between the 600-mm and 660-mm isohyets in Victoria *E. melliodora* is associated with *E. aromaphloia* and *E. elaeophora* on Luvisols. In southern Victoria and the southeast of South Australia *E. camaldulensis* is dominant in woodlands on Solodic Planosols derived from either basalt or alluvium. Associate species are *E. viminalis* and — particularly in wet situations — *E. ovata*. In South Australia the characteristic species is *E. leucoxylon* which commonly occurs on Calcic Luvisols, Solodic Planosols, Orthic Solonetz and Orthic Luvisols. It is frequently the only tree species but may be associated with *Acacia pycnantha* or *Casuarina stricta*. In the southwest of Western Australia the principal tree species on Planosols and Solonetz soils are *E. fecunda* var. *loxophleba* and *Acacia acuminata*. In Tasmania *E. pauciflora, E. ovata* and *E. salicifolia* are associated in woodlands on Planosols derived principally from dolerite. The understorey shrubs are commonly *Banksia marginata* and *Acacia dealbata*.

The species dominant in the herbaceous layers of all these woodlands, at least in eastern Australia, were *Themeda australis, Poa caespitosa* sens. lat., and *Stipa aristiglumis*. As a result of grazing by sheep these relatively tall species, notably *Themeda australis*, have been replaced with shorter species: *Danthonia auriculata, D. carphoides* and *Stipa falcata*.

Temperate woodlands are used for sheep and cattle grazing, and large areas on Planosols and Solonetz soils have been fertilized with superphosphate and sown with *Trifolium subterraneum*, a self-regenerating annual. Besides phosphorus and sulphur the soils are frequently deficient in molybdenum and sometimes in potassium.

Below 480 mm of annual rainfall in the south and approximately 690 mm in the north the principal species of large areas of temperate woodlands are the grey boxes, *Eucalyptus microcarpa* and *E. woollsiana*, formerly grouped under *E. hemiphloia*. Grey boxes are associated with *Casuarina luehmannii* on Chromic Vertisols, with *Callitris columellaris* on sands, *Angophora floribunda* on gravels and *E. conica* on Fluvisols. Counterparts of the grey box communities are the *E. odorata* and *E. leucoxylon-E. calcultrix* woodlands on Calcic Luvisols and Orthic Solonetz soils in South Australia, and the *E. sal-*

monophloia and *E. salubris* woodlands in Western Australia.

Semiarid shrub woodlands (3c). This subformation lies between the subhumid woodlands of northern and eastern Australia, where crops and pastures of introduced species can be sown, and the arid communities of the interior. The shrub woodlands merge with the drier *Acacia* shrublands and with the mesophytic tropical and temperate woodlands, but as a result of soil and topographic changes there are sharp boundaries with some other communities. The effect of soil on vegetation is shown by the outliers of arid grasslands, shrub steppe and brigalow which occur on heavy-textured soils within the shrub woodlands. Shrub woodlands usually have an overstorey of eucalypts above a shrub layer of species belonging commonly to Myoporaceae, Leguminosae and Rutaceae.

At approximately latitude 20°S in eastern Australia there is a shrub woodland of *E. microneura* commonly associated with *Erythrophleum chlorostachys* on Luvic Yermosols, Planosols, Solonetz, Regosols and Lithosols.

Eucalyptus melanophloia, which grows as far south as latitude 30°S, occurs in extensive shrub woodlands between latitudes 25 and 20°S. The common grasses are *Triodia mitchellii* (buck spinifex) and *Aristida* spp. Woodlands of *Eucalyptus populnea* extend southward from latitude 23°S to approximately 35°S, at longitude 144°E. *E. populnea* grows on a variety of soils from Chromic Vertisols to Regosols but the most typical are Planosols, Solonetz and Luvic Yermosols.

Acacia pendula woodlands occur on Chromic Vertisols, Calcic Luvisols and Orthic Solonetz from southern Queensland to the Riverina of southwestern New South Wales. A former tall shrub associate, oldman saltbush (*Atriplex nummularia*), has now largely disappeared. Smaller shrubs, *Enchylaena tomentosa*, *Rhagodia spinescens* and *Kochia aphylla*, are common. Herbaceous species vary according to soil texture: *Stipa variabilis* is dominant on light-textured and *Danthonia caespitosa* on heavy-textured soils.

Shrub woodlands are used largely for sheep grazing, and the control of tree and shrub regeneration following initial thinning is a technical and economic problem of some magnitude (Moore, 1972).

Arid and semiarid low woodlands (3d) occur at the drier limits of the woodland formation. A low woodland of *Eucalyptus brevifolia* extends from the Kimberleys in Western Australia to western Queensland on shallow stony Haplic Yermosols and Lithosols between the 380-mm and 680-mm annual isohyets. *E. brevifolia* is replaced by *E. argillacea* and *E. terminalis* on soils derived from basic parent materials. In the northern and higher rainfall areas of the *E. brevifolia* community *E. dichromophloia* and *E. pruinosa* become fairly common. Shrubs include *Atalaya hemiglauca*, *Grevillea striata* and *Petalostigma banksii*. The grasses are mainly species of *Aristida*, but at the drier limits of the community *Triodia pungens* becomes dominant.

A *Eucalyptus pruinosa* woodland extends westward from the Kimberleys in Western Australia between the 430-mm and 630-mm annual isohyets to the Gulf of Carpentaria. There is a sparse shrub layer of *Atalaya hemiglauca*, *Grevillea striata* and *Cassia lanceolata*. The principal grasses are *Aristida pruinosa*, *A. inaequiglumis*, *Sehima nervosa* and *Chrysopogon fallax*. The soils are Luvic Yermosols. In the Northern Territory between latitudes 15 and 18°S and the 430-mm and 670-mm annual isohyets there are low woodlands of *Eucalyptus dichromophloia* and *Acacia shirleyi* (lancewood). *Aristida pruinosa* and *Sehima nervosa* are the common grasses in both communities, except at the arid boundary where *Triodia* spp. (spinifex) becomes dominant. The soils are mainly Haplic and Luvic Yermosols containing ironstone gravels.

Between latitudes 19 and 21°S and longitudes 143 and 141°E there is a low woodland of *Bauhinia cunninghamii* and *Melaleuca viridiflora* on Ferralic Arenosols and Acrisols.

In New South Wales between the Darling river and Cobar there is a low woodland or shrubland of many of the species forming the understorey of the semiarid shrub woodlands. In southern New South Wales the driest of the woodland communities is a low woodland of *Casuarina cristata* and *Heterodendron oleifolium*. This is west of the 350-mm annual isohyet and occurs on Calcic Xerosols.

4. *Shrublands*

These are communities dominated by woody plants generally less than 8 m tall and multistemmed.

Shrub steppes (4a) are composed of chenopod shrubs, seldom more than 2 m and generally 1 m or less in height; shrub density varies from scattered isolated plants to dense stands of 500 per ha. They mainly occur in areas receiving less than 250 mm rain annually of which one third or more falls in the winter months. The spaces between shrubs, bare of vegetation during dry periods, are covered with grasses and forbs after rains. Shrub steppes often consist of a single species, but mixtures of shrubs do occur. The principal species are *Atriplex vesicaria* and *A. rhagodioides* (saltbushes), and *Kochia* *pyramidata* and *K. sedifolia* (blue bushes). *Stipa variabilis* is the characteristic grass of the southern shrub steppe, but a larger number of short-lived species may be present after summer rains. Shrub steppes are found on Haplic and Calcic Xerosols, Orthic Solonetz and Chromic Vertisols. They are mainly used to graze sheep.

Acacia shrublands (4b) occur widely throughout the arid zone. Characteristically they have a monospecific layer of tall shrubs, usually less than 7 m but occasionally as high as 10 m.

Mulga (*Acacia aneura*) is the largest and most widespread of the *Acacia* shrublands. It commonly occurs on Luvic and Haplic Yermosols, Ferralic Arenosols and red Dystric Regosols. Other species of *Acacia* on calcareous soils are myall (*Acacia sowdenii*) in South Australia, witchetty bush (*A. kempeana*) in central Australia, and gidgees (*A. georginae* and *A. cambagei*) in northern Australia. The common grasses of *Acacia* shrublands are *Eragrostis eriopoda, Danthonia bipartita, Aristida* spp. and *Eriachne* spp. *Acacia* shrublands are used for grazing beef cattle in the north and wool sheep in the south.

Eucalypt shrublands (*mallee*) (4c) are communities of eucalypts which produce several branches from an enlarged lignotuber below the soil surface. The height of mallee eucalypts ranges from 1 to 12 m. In its drier phases mallee has affinities with shrub steppe, and in its wetter phases with mallee heaths, heaths, and dry sclerophyll forests.

Red mallee (*Eucalyptus oleosa*) is the most common eucalypt of arid mallee on Calcic Xerosols. It is frequently associated with *Myoporum platycarpum, Heterodendrum oleifolium, Cassia sturtii* and *Kochia sedifolia.* At the driest limits of mallee (approximately 200 mm annual rainfall), *Atriplex stipitata* and *A. vesicaria* may become important components. Between 280 and 460 mm of annual rainfall the commonest eucalypts in mallee are *E. dumosa, E. oleosa* and *E. gracilis.* The community is dense and there are several species of shrubs, the most common being *Melaleuca parviflora, Dodonaea bursariifolia* and *Acacia* spp.

The soils are generally Solodic Planosols and Orthic Solonetz, acid at the surface but frequently with lime deeper in the profile, and deep siliceous sands. On Planosols and Solonetz soils where the sandy horizon is less than 50 cm deep *Eucalyptus incrassata* is associated with *Melaleuca uncinata* in a mallee-broombush community. Where the sand layer is deeper than 50 cm the community grades into heath.

Arid mallee is used largely for grazing. *Stipa variabilis* may be locally important, and *Triodia irritans* forms fairly dense communities on sandy soils. However, particularly in the ecotone between eucalypt shrublands and shrub steppe, the principal contributors to grazing are *Bassia* spp. and other chenopods. Most of the eucalypt shrublands receiving more than 280 mm of rain annually have been cleared for cereal farming. In the phases between crops volunteer communities of introduced annuals, *Medicago polymorpha* and *Hordeum leporinum,* provide grazing for sheep.

5. *Grasslands*

The most extensive of these communities, dominated by grasses and for the most part treeless, are in arid areas.

Arid tussock grasslands (5a). Species characteristic of arid tussock grasslands are the Mitchell grasses (*Astrebla* spp.). They are perennial, 0.5-1 m in height, and generally grow in discrete tussocks 0.5 m or more apart. The intertussock areas are normally bare of vegetation but are covered with annual grasses and forbs after rains.

In the tussock grasslands of the Northern Territory and Western Australia the common species is *Astrebla pectinata* (barley Mitchell grass). *Astrebla lappacea* (curly Mitchell grass) is the species most characteristic of the Queensland arid tussock grasslands. *A. squarrosa* (bull Mitchell grass) and *A. elymoides* (weeping Mitchell grass) are prominent in the wetter margins. There are usually few perennial grasses other than Mitchell grasses in arid tussock grasslands, but *Aristida latifolia, Dichanthium fecundum, Panicum whitei, Eragrostis setifolia* and *E. xerophila* may be important constituents under some conditions. In some areas there are scattered shrubs; the most frequent of these are *Acacia farnesiana* (mimosa) and *A. nana* (boree). Water courses throughout the tussock grasslands are lined with *Eucalyptus microtheca* (coolibah). Annuals appearing after rain include *Iseilema* spp. (Flinders grasses), *Dactyloctenium radulans, Tragus australianus,* and several composites. The soils are Chromic Vertisols. The grasslands are used for sheep grazing except in the more northern areas where cattle are run.

Arid hummock grasslands (*spinifex*) (5b) are the most extensive of the grassland communities. The characteristic species are the spinifex grasses, *Triodia* spp. and *Plectrachne* spp., which are perennial, evergreen, highly lignified and hummock forming. Hummocks are normally about 1 m in diameter and 0.5 m high, but may be 6 m in diameter and 1.8 m high in *Triodia longiceps. Triodia basedowii,* a species which becomes annular in form because of the death of the centre of the hummock, is common on siliceous sands in areas receiving up to 350 mm rain annually. In northern areas, *T. pungens* is the most frequent species on Ferralic Arenosols, red Dystric Regosols and Lithosols.

Other herbaceous species are rare, and the scattered trees and shrubs are usually less than 2 m high. For the most part arid hummock grasslands provide little grazing.

Coastal grasslands (5c) occur on marine plains in northern and northeastern Australia; the seaward sides of the plains are usually saline mudflats, bare or sparsely covered with *Arthrocnemum* spp. (samphires), *Suaeda australis*, *Salsola kali* and *Tecticornia cinerea*. The soils are Chromic Vertisols or Solonchaks.

Subhumid tropical grasslands (5d) of *Eulaia fulva*, *Dichanthium fecundum* and *D. tenuiculum*, the browntop-bluegrass downs, are widely distributed on Chromic Vertisols in northeastern Australia, but only in a few places are they extensive enough to be shown at the scale of the accompanying map. The community, a humid expression of the arid tussock grassland, usually occurs on heavy-textured soils where the annual rainfall exceeds 625 mm.

Subhumid temperate grasslands (5e) are of two types: those on Pellic and Chromic Vertisols and those on Solodic Planosols and Orthic Solonetz soils. The principal species on heavy-textured soils were originally *Themeda avenacea* and *Stipa aristiglumis*, but the former has largely disappeared as a result of grazing by sheep. These grasslands occur from latitude 28°S and an annual rainfall of 690 mm, to latitude 37°S and a rainfall of 420 mm. They are commonly farmed for wheat and other grains, and require applications of phosphorus and sulphur, and sometimes of zinc.

Temperate grasslands on texture-contrast soils are now composed largely of *Danthonia carphoides*, *D. auriculata* and *Stipa falcata*. Originally the principal species were *Themeda australis*, *Stipa aristiglumis* and *Poa caespitosa* sens. lat. These grasslands, which occur in small patches throughout the temperate woodlands of the southern tablelands of New South Wales and western Victoria, are used largely for grazing wool sheep.

6. *Alpine communities*

The alpine and subalpine areas of Australia are restricted to the southeast, and occupy less than 1 200 sq km in New South Wales, Victoria and Tasmania. The lower limit of the subalpine zone is 1 400-1 500 m on the mainland and 910 m in Tasmania. At these altitudes eucalypt forests are replaced by subalpine woodlands of *Eucalyptus niphophila* on the mainland, and *E. coccifera* and *E. gunnii* in Tasmania. The tree limit is about 1 830 m on the mainland; above this altitude there are tall alpine herbfields and heaths. In Tasmania the upper limit of tree growth is 1 220 m; above this the vegetation is largely alpine heath.

Other communities

Dune communities. Plants typical of sand dunes in the arid interior are *Zygochloa paradoxa* (cane grass), *Triodia basedowii* (spinifex), *Salsola kali*, *Plagiosetum refractum* and *Eriachne aristida*. The commonest species of interdune areas are *Acacia* spp. and *Triodia basedowii*. The principal species of the fore dunes of coastal areas are *Spinifex longifolius*, *Oenothera drummondii* and *Ipomoea pes-caprae* in northern Australia, and *Atriplex cinerea*, *Cakile maritima* and *Festuca littoralis* in the south.

Stabilized dunes in the north often have a hummock grassland of *Triodia* spp. on the lee side, and *Casuarina equisetifolia*, *Salsola kali*, *Scaevola sericea* and *Suriana maritima* on the windward side. The common species of semistabilized coastal dunes in southern Australia are *Spinifex hirsutus*, *Hibbertia volubilis*, *Lepidosperma* sp., *Scirpus nodosus* and *Scaevola* sp. On stabilized dunes the community is usually composed of *Acacia longifolia*, *Olearia axillaris*, *Leptospermum laevigatum*, *Correa alba* and *Leucopogon* sp.

Mudflat communities. Coastal mudflats are generally occupied by mangroves. In the north there is a zonation of species from the water inshore: *Avicennia marina* and *Sonneratia alba* at the sea edge are followed by *Rhizophora stylosa* and *Bruguiera* spp., and then frequently by other species of *Avicennia*. In the south *Avicennia* spp. occur alone or in combination with *Aegiceras* spp.

Saltpan communities. The most constant species of both coastal and inland saltpans are *Arthrocenemum* spp. Others frequently present include *Suaeda australis*, *Salsola kali*, *Tecticornia cinerea* and, in the interior, *Bassia* spp.

Introduced plants. There are about 1 300 exotic species introduced accidentally or intentionally and now naturalized in Australia. Many of these are weeds, such as *Chondrilla juncea* which has established on Calcic Luvisols, Orthic Solonetz, Solodic Planosols and Calcic Xerosols in many of the principal wheat-growing areas of southern Australia. Subterranean clover (*Trifolium subterraneum*), accidentally introduced originally, is now sown in extensive areas of southern Australia. In combination with other introduced species, *Lolium rigidum*, *Phalaris tuberosa* or *Arctotheca calendula*, it is the principal species of pasture communities on Solodic and Dystric Planosols, Orthic Solonetz and Luvisols in areas formerly under temperate woodlands or dry temperate forests. Subterranean clover is commonly sown with dressings of superphosphate and, particularly in forest areas, molybdenum. On temperate heath soils copper and zinc may be required in addition to molybdenum, sulphur and phosphorus. On the Calcic Luvisols, Orthic Solonetz and Chromic Vertisols of temperate woodlands the commonly naturalized species are *Medicago minima*, *M. polymorpha* and *Hordeum leporinum*. These species have established without fertilizers.

The counterpart of subterranean clover in tropical woodlands is Townsville stylo (*Stylosanthes humilis*), an accidentally introduced species. It is now widely established by sowing and by natural spread on an extensive range of soils other than Vertisols, in areas receiving for the most part more than 700 mm of rain annually.

The establishment of *Trifolium* and *Stylosanthes* and the consequent increase in soil nitrogen (and of sulphur and phosphorus from superphosphate applications, particularly in southern areas) have created conditions favourable for other introduced species. As a result of this, and of grazing by sheep and cattle, the vegetation and character of much of the woodland zone are changing, and differences between the ground flora of many communities are being obliterated.

PAPUA NEW GUINEA

Natural vegetation, mainly rain forest, still covers three quarters of Papua New Guinea. The 20 000 species have strongest affinities with the Indo-Malaysian flora, but Australian and Pacific elements also occur. The plant communities range from mangroves through swamp land, savanna, grassland and forests to alpine vegetation.

The grasslands represent man's greatest impact on vegetation. They are probably a result of shifting agriculture and regular firing, and although little used at present have a potential for cattle raising. The lowland rain forest is the most extensive vegetation type, being found in areas up to 1 000 m in altitude with well-distributed rainfalls exceeding 1 500 mm a year. It is very mixed, with many timber trees. Flange-buttressed trunks, palms and rattans, woody lianes and epiphytes are all characteristic. Lower montane forest (1 000 to 3 000 m) is also extensive. It includes oak-laurel (*Castanopsis-Cryptocarya*), mixed Elaeocarpaceae-Cunoniaceae, and southern beech (*Nothofagus*) forest. Montane forest, above 3 000 m, includes Myrtaceae, conifers and other temperate species. It reaches up to 3 900 m, and through conifers grades into subalpine scrub and grasses. From 3 900 to about 4 300 m temperate tussock grasses (*Danthonia*, *Poa*) dominate with alpine bogs and a tundra-like vegetation of ferns, lichens and mosses (Robbins, 1970). The vegetation types of Papua New Guinea are also shown on a map, scale 1 : 1 000 000 published by the CSIRO Division of Land Use Research (Paijmans, 1975).

NEW ZEALAND

When Polynesian man reached New Zealand more than a thousand years ago the vegetation was still in a state of flux following the retreat of the last ice sheet in the south, and the widespread devastation of vast volcanic outbursts in the north. The thousand years of Maori occupation introduced the repeated firing that burned forest that could be burned, and prevented regeneration of forest destroyed by volcanoes or adversely affected by climatic change. Tussock grassland, fern and scrub were therefore widespread when Europeans arrived in the nineteenth century. Other forest, in regions not permanently settled by Maoris and where burning was difficult, gave way to the steel tools and more efficient firemaking of the Europeans, so that today less than one quarter of the land remains in forest. The use of this indigenous forest for timber is now diminishing as extensive exotic pine forests mature.

The primitive vegetation of the soil associations is shown broadly in Chapter 5. The units used are:

Podocarp-mixed broadleaf forest characterized by *Podocarpus* and *Dacrydium* species associated with many hardwoods. In the far north kauri (*Agathis australis*) was frequently present with numerous other hardwoods.

Beech and beech-podocarp forests were dominated by one or more of the southern beech (*Nothofagus*) species, usually mixed with species of the podocarp-mixed hardwood forest.

Lowland short tussock grassland, generally with *Poa* and *Festuca* species dominant, occurred mainly in the seasonally dry eastern regions below 1 000 m.

Subalpine grassland. Snowgrass (*Chionochloa* spp.) was widely distributed on the South Island mountains above 1 000 m. It occurred with herbfield, moorland, scrubland and subalpine barrens.

Lowland tall tussock grassland, with *Chionochloa rubra* as the physiognomic species, occurred in the far south and on high plateaus in the central North Island. It was interspersed with swamp, scrub and forest.

Scrub and fern lands were variable but bracken fern and manuka (*Leptospermum*) were usually dominant. To a large extent these were induced by fire.

Swamp lands were widespread, often with New Zealand flax (*Phormium tenax*) dominant. These also were largely induced by fire. Sphagnum and manuka were found in the bogs amid islands of swamp and bog forest.

Dune lands are moving sands with little vegetation, and *alpine barrens* occur in the high mountains, also with limited vegetation (Holloway, 1959).

The vegetation pattern today (Taylor *et al.*, 1959) is strikingly different from the primitive pattern. Almost half the country is under grass used for sheep, cattle or dairy farming. A quarter, mainly in mountain regions, is still under forest, and the remainder, apart from a million hectares used for field crops, gardens, orchards and exotic forests, is undeveloped or used unproductively. These uses are noted in Chapter 5 in the table of soil associations.

SOLOMON ISLANDS

The Solomons archipelago is part of the Melanesian foreland from Bougainville to San Cristóbal. The vegetation is almost entirely tropical rain forest, with occasional small anthropogenous grassland on the drier lee sides of the larger islands. The flora of the Solomons is similar to that of its neighbours but impoverished, with fewer families, genera and species, and there is a small but distinctive group of genera, some of which have a Pacific-wide distribution. There is hardly any sign of New Caledonian influences in the flora of the Solomons, and some genera, such as *Agathis*, occur in both New Guinea and the Santa Cruz group but are absent from the Solomons. Whitmore (1969) has described the flora as monotonously uniform from island to island.

In the lowland rain forest there are about 12 very common tree species in the canopy, and only about 60 big tree species are common. Climbers and epiphytes occur throughout and the undergrowth contains an abundance of small trees and palms. Steep, unstable slopes have a poor forest cover which is disturbed by land slips initiated by earth tremors. Occasional cyclones also damage areas of forest by defoliating and destroying the canopy and encouraging the growth of secondary species. Man has had a widespread effect on the forests as the populations of many islands were once more numerous. Whitmore (1969) suggests that the extensive areas of *Campnosperma brevipetiolata*-dominated forest on western Santa Isabel probably result from widespread cultivation in the past. Apart from a few isolated high-level areas there is probably little truly primary forest, and secondary vegetation at all stages of regrowth covers much of the Solomons.

A distinctive variant of lowland forest occurs over ultramafic rocks on some islands. This forest is species poor and dominated by *Casuarina papuana*, while other commonly occurring species such as *Podocarpus* sp. and *Dacrydium xanthandrum* are seldom found on parent materials other than ultramafics, and four species are restricted solely to ultramafics.

Mangroves are well developed and represented mainly by *Bruguiera* spp. and *Rhizophera* spp. Freshwater swamps often contain pure stands of *Terminalia brassii*, although *Metroxylon salomonense* and *Pandanus* may form distinctive communities in some areas.

The forests of the Solomons change rapidly with increasing altitude, and low stunted forest resembling the montane forest of high levels in Papua New Guinea occurs as low as 690 m (Whitmore, 1969). Many of the genera that occur in montane vegetation in Papua New Guinea are absent from the Solomons, in particular *Nothofagus* sp., *Castanopsis* spp. and *Araucaria* spp.

NEW CALEDONIA

Most of New Caledonia is covered with low, open herbaceous or woody herbaceous savanna and scrub (maquis). The once extensive forests are now found only in the hills and mountains.

There are three formations in the savannas:

(*i*) a low formation of *Acacia farnesiana* with a grass cover of *Botriochloa pertusa* and *Dicanthium aristum* on Rendzinas and Eutric Cambisols occurs beside the sea on the west coast;

(*ii*) a grass formation of *Heteropogon contortus* is found on Eutric Cambisols of basaltic hills. This formation may pass locally to *Leucena glauca* scrub or, in the north, to a savanna with *Themeda* grasses;

(*iii*) a formation of savanna with trees or niaouli shrubs, *Melaleuca quinquenerva* occurs mainly on Ferric Acrisols and Dystric Nitosols. The niaouli is believed to have a podzolizing effect on the soils. The grass layer is then composed of *Heteropogon contortus*, *Imperata cylindrica* and sometimes, in the most acid soils, of the fern *Dicranopteris*.

The savannas are generally used as natural pastures, the best being the *Acacia farnesiana* formation.

The maquis scrub is mainly developed on ultrabasic rocks, where it has a very rich and unique floristic composition. Maquis is also found on some very acid stony Dystric Regosols, where it is much poorer floristically.

Dense forest occurs on all kinds of terrain in the wettest zones and those with difficult access or unsuitable for agriculture. These cover 10 percent of New Caledonia.

The weak plant cover and its continual degradation by fire and mining activities are factors favouring erosion.

PACIFIC OCEAN

The vegetation of the Pacific is Indo-Malayan in origin, with, however, many endemic species. It is richest in the west, and New Guinea appears to be a centre of distribution.

Strand vegetation is the only cover on most of the low islands and is important around the high islands. The salt-tolerant coconut, whose seed can survive long immersion in sea water, is a typical member. Others include *Pandanus*, casuarinas and cycads. The number of species is small.

Tidal vegetation is dominated by mangroves, which are widespread in New Guinea and extend east to Samoa and south to New Zealand. To the west nipa palms border the saline zone.

Rain forest occupied wet aspects of high islands. It was dense evergreen forest with heavy undergrowth, and like its counterpart in New Guinea had a large number of species, including timber trees (Robbins, 1972). In drier areas the forest was more open. This forest has now given way in many parts to scrub.

Grasslands, as in New Guinea, occur on some of the larger islands. Repeated burning has extended these areas, and they are now becoming important in the development of livestock industries.

PHYSIOGRAPHY

AUSTRALIA [1]

The landforms of Australia exhibit general traits which are significant for an understanding of the associated soils. Chief among these is a limited range of altitude and relief. The greater part of the continent consists of extensive plains at altitudes between 150 and 450 m, mainly as an interior plateau or lowland bounded by a dissected marginal zone. Only limited areas exceed 1 200 m, almost entirely in the Eastern Uplands where Mount Kosciusko at 2 228 m forms the summit of the continent. Even the upland surfaces are subdued, with dissected tablelands predominating. This relief assemblage results from a fairly stable tectonic history with predominant epeirogenic movements since the Palaeozoic, terminating with the Cainozoic Kosciuskan uplift which set in progress the present dissection of the continental margins. In consequence of this restricted relief, overall rates of erosion are low and there are extensive stable surfaces, many of them ancient and with relict weathering profiles and inherited soils.

A second important feature is the great extent of desert landscapes, as more than two thirds of Australia is arid. Most extensive of the characteristic desert forms are the sandplains and dunefields, but another desert aspect is the prevalence in the interior of disconnected ephemeral river systems with vast alluvial plains in their lower sectors and numerous terminal lake basins, many of them saline.

The desertic character of Australia is accentuated by the peripheral distribution of higher ground, an expression of the fact that the Kosciuskan uplift was greatest along the margins of the continent, and conversely by the depression of the interior, where the lowlands descend to 16 m below sea level in Lake Eyre. Accordingly the main drainage divide generally runs close to the continental margin and coastal plains are characteristically narrow and discontinuous; the seaward rivers are short, and much of Australia is drained by large river systems directed inland.

Continental form and outlines

Australia has three major geomorphic provinces (Figure 11), which reflect distinctive assemblages of structural units. The Western Plateau consists of a stable Precambrian block and its younger marginal basins, the Interior Lowlands, correspond to a series of relatively depressed sedimentary basins with generally weak rocks which have locally been deformed, and the Eastern Uplands are a mosaic of Palaeozoic orogenic blocks and intervening younger sedimentary basins, in a zone which was differentially uplifted in the Cainozoic era.

Patterns and status of drainage

The pattern of continental drainage reflects the marginal distribution of higher ground, differential Cainozoic earth movements in the Interior Lowlands, and the extent of arid climates.

The zone of direct external drainage occupies only a third of the continent. Its rivers are relatively

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[1] The material for this section was supplied by Prof. J.A. Mabbutt, Department of Geography, University of New South Wales, Kensington, N.S.W.

short and contrast with the large inward-directed drainage systems of the Interior Lowlands in which centripetal patterns reflect the tectonic slopes of individual structural basins. The Murray-Darling system in the southeast, for instance, has a catchment of about 1 million sq km, and the area of interior drainage tributary to Lake Eyre is somewhat larger. Generally, the peripheral divide is also the limit of drainage to the ocean, and the only major *indirect* external drainage is the Murray-Darling system, where higher rainfall in the southern part of the Eastern Uplands has enabled the main streams to persist across semiarid lowlands to reach the sea.

Over much of the continent there is a close accordance between the peripheral divide and the limit of the arid zone, and consequently the division between external and interior drainage is also generally that between perennial or seasonal rivers and ephemeral rivers. Much of the ephemeral drainage of the arid interior is disconnected, with several separate drainage systems occupying a single topographic basin.

Relict land surfaces

Tectonic stability, small relief and a dry climate, through their limitation of vertical erosion, have favoured the development and survival of planate land surfaces. The form and extent of such surfaces vary with age and degree of subsequent uplift and dissection. For instance, they are found as extensive fossil plains and low tablelands over much of the interior, while along the rim of the continent they survive as restricted high-standing upland surfaces and summit remnants. These relict surfaces affect the present-day pattern of Australian soils in various ways: in some areas they preserve, virtually intact, fossil soils formed under differing past climates; elsewhere, associated weathering profiles have been stripped or truncated and now provide parent material for younger soils; in other areas, only the subdued forms of old land surfaces have remained, to influence subsequent pedogenesis mainly through their control over the regional dynamics of erosion or deposition and weathering. This close genetic association of soils with ancient land surfaces has meant that geomorphic history has always been relevant to soils studies (Stephens, 1961). It has, for instance, been claimed that the great age and advanced weathering of many land surfaces are factors in the general low mineral nutrient status of Australian soils (Wild, 1958).

In a review of Australian cyclic land surfaces, King (1950) claimed to recognize a sequence of planations comparable with that in other southern continents, namely summit remnants of Mesozoic age relating to an ancestral Gondwanaland, a major Australian pediplain initiated by the detachment of the Australian continent in the Cretaceous, and a group of younger, more local surfaces generated by differential and intermittent Cainozoic uplift. The scheme, with its implications for the evolution of the continent, has not been generally adopted by geomorphologists, but the concept of a continent-wide surface of planation and deep weathering, which has been disrupted by the encroachment of younger cycles of erosion and above which survive older summit remnants, provides a realistic framework for a consideration of landscape inheritance as a factor in the development of Australian soils.

The continent-wide or Australian land surface

This weathered land surface, which is identified with the Australian pediplain of King (1950), may well be geomorphologically complex, for the associated hard capping or duricrust commonly displays evidence of reworking and of further chemical alteration; nevertheless it stands out clearly from older and younger relict surfaces by virtue of its continental extent, degree of planation, and depth of weathering. The characteristic duricrust is commonly massive and is generally formed in the top surviving horizon of a profile of weathering which may be more than 30 m deep. This typically exhibits a thick pallid or kaolinized zone in which bedrock structure is preserved below a disturbed and thinner iron-mottled horizon which underlies and which may grade into the duricrust. The duricrust is ferruginous or lateritic in the west, north and east of the continent, but is mainly a silcrete in south central Australia. Soil landscapes characteristically associated with the lateritic crust include the desert sandplains, as on the Old Plateau surface of Western Australia. The silcretes form strong tablelands in east central Australia, with associated desert loam soils and strong gilgai microrelief, and land surfaces at lower levels are extensively mantled with silcrete gravels or gibbers.

Duricrusting has affected rocks ranging to Miocene in age, and Dury *et al.* (1968) have proposed a minimum age of about 14.5 million years for duricrust transitional between laterite and silcrete in north central New South Wales, based on radiometric dating of an overlying lava sheet. Considering the extent and possible physiographic complexity of the duricrusted surface, and in view of the fact that the duricrust may mark the achievement of regional land surface stability rather than a distinct climatic episode, the episode of deep weathering and the development of a planate land surface with its associated duricrust may well have ranged from Cretaceous to Pliocene.

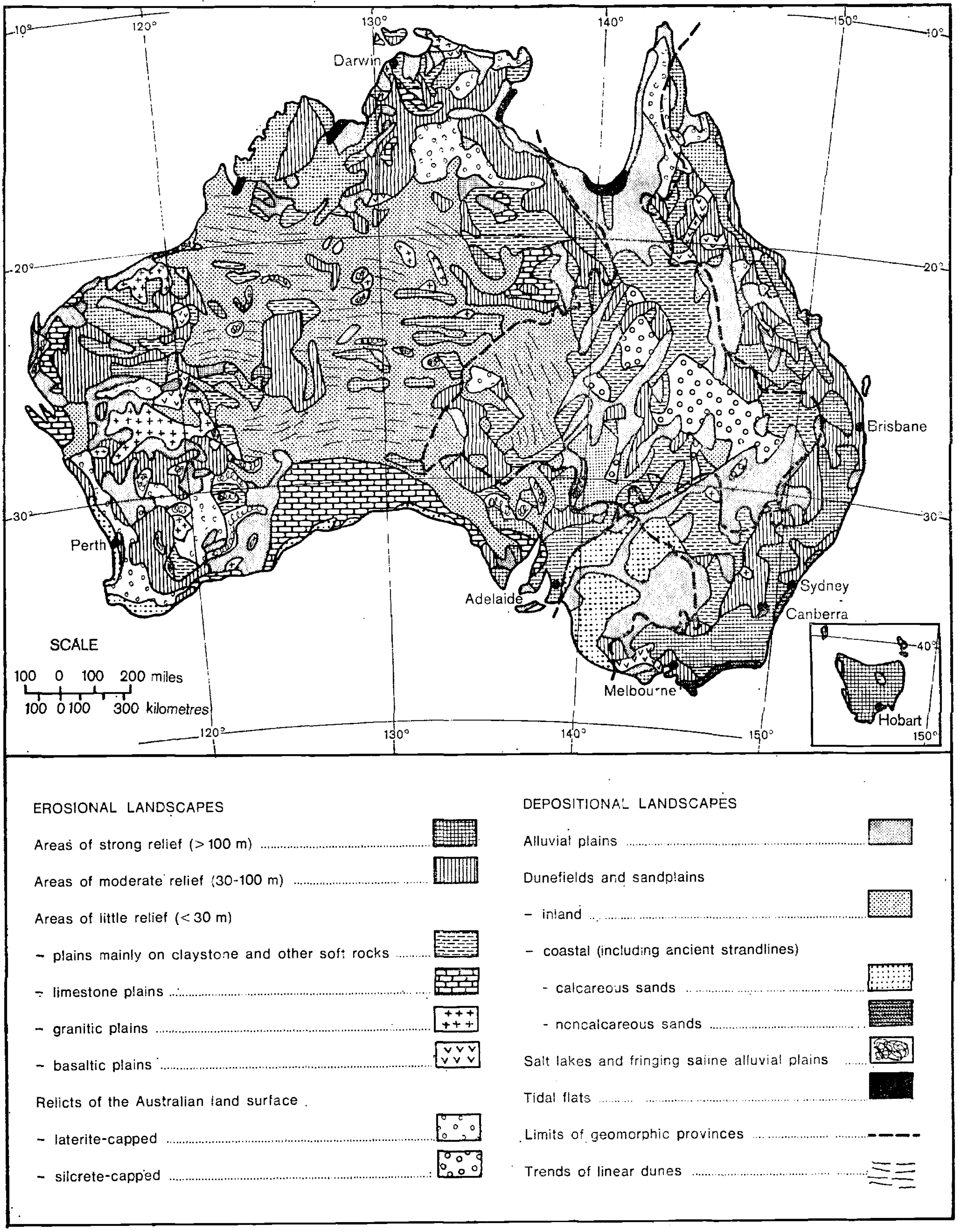

Figure 11. Landforms and geomorphic provinces in Australia

Summit bevels above land surface

Summit planes occur above the main duricrusted surface locally, mainly preserved on resistant rocks in tectonically stable areas, for example the summit bevels across the folded Ashburton, Davenport and Macdonnell ranges in the Northern Territory. The duricrusted land surface abuts against such higher residuals in the form of piedmont benches and extends between them as relict lowland plains. In both the Northern Territory and western Queensland, downwarped extensions of these ancient remnants appear to pass beneath Lower Cretaceous strata, suggesting a Mesozoic age.

Younger land surfaces

Surfaces formed subsequently to the main duricrust generally exhibit features more consistent with the present-day environment, particularly the contrast between the wetter continental margin of the north and east and the drier interior, south and west. For example, late Cainozoic surfaces in interior Australia are largely depositional, with extensive fluviatile and lacustrine cover indicating widespread interior drainage. Doubtless this in part reflects the tectonic warping of the duricrust that set in train its dissection; however an associated aridity is indicated by the prevalence on these depositional surfaces of crusts indicative of incomplete leaching.

The forms of these younger surfaces and their topographic relationships with the older weathered land surface largely depend on the amount of deformation and subsequent dissection undergone by the latter. In some stable shield areas, lacustrine and fluviatile limestone has buried the intact laterite duricrust and now shows as higher level cappings where it has since been dissected. In Western Australia, however, the weathering front of the old pallid zone has controlled the etchplanation of a younger surface on little-weathered rock.

In basin areas one or more unleached surfaces may be staged beneath the silcrete. In the western Lake Eyre basin these are extensively mantled with calcrete, but near the centre of the basin gypsite crusts are characteristic. On the lowlands east of Lake Eyre there is a single step from the silcrete to the " rolling downs " of the present cycle.

The equivalent land surfaces in the more vigorously uplifted and dissected continental margins show greater vertical separation and commonly exhibit advanced weathering under the prevailing comparatively moist regimes, albeit less pronounced than that of the main duricrust, from which they commonly incorporate weathered materials. Lateritic profiles occur on plateaus and valley plains below the summit duricrusts in the uplands of the northern and western margins. In the southeast, however, the tableland surfaces have been largely stripped of weathered profiles, leaving tor fields in areas of disaggregated granite; only the Cainozoic basalts preserve the laterites locally.

Geomorphic regions and landform development

The three major geomorphic provinces and their constituent landform types are shown in Figure 11. The major division is that between erosional and depositional landscapes, the former showing in the main a marginal occurrence. Characteristic relief is used as a measure of the vigour of erosion; however there is a fundamental difference between the upland landscapes of the humid zone (with mainly soil-covered, vegetated slopes subject to slow mass movement, gullying, and limited slope wash, and drained by seasonal or perennial rivers) and the uplands of the desert region with bare rocky slopes vulnerable to wash erosion and with ephemeral drainage channels. Erosional lowlands are subdivided according to the prevailing lithology, the chief contrast being that between the granitic plains of shield areas, with domes of crystalline rock, and basin lowlands of soft sedimentary rock in which upland forms are mainly duricrusted. The main depositional landscape is that of the desert dunefields and sandplains, but extensive alluvial plains also exist in the Interior Lowlands.

The geomorphic provinces are distinguished by underlying structural controls. In the geologically stable areas, such control reflects a long erosional adjustment to structure and lithology, sharpened under the prevailing aridity; in the marginal uplands, later epeirogenic movements have rejuvenated ancient structures, and the resulting dissection has revived old geological boundaries. In addition, particularly in the Interior Lowlands, some landforms are the direct expression of youthful earth movements.

Landforms of the Western Plateau

The interior plateau and uplands of this geomorphic province are formed on a stable Precambrian block or craton, comprising shield areas in which the crystalline basement is exposed and a larger extent of platform with cover rocks. Narrow coastal lowlands have formed on younger marginal sedimentary basins.

Landforms of the crystalline shields

The shield blocks are of two types, namely broad arches with extensive exposures of gneiss and granite and lesser tracts of metamorphic rocks, and narrower folded belts in which metamorphic rocks with strong structural trends predominate.

One of the broad shield areas is the Yilgarn block in the southwest of Western Australia, in which the gneissic basement has been reduced to an extensive interior plateau at 300-500 m altitude. Folded shield blocks are represented by the Mount Isa geosyncline in Queensland, a zone of strong deformation, metamorphism and igneous intrusion, differentially eroded into a complex of granitic domes, schist ridges, and massive ranges and plateaus of quartzite.

Landforms of the platform cover

These reflect a range of structures and rock types relating to the various types of cratonic basins.

Folded basins have given rise to spectacular ranges, as in the Macdonnell ranges of the Amadeus basin, with sandstone ridges and strike lowlands on shale. Uplifted basin structures with peripheral warping have yielded bold plateaus with bounding ranges, as in the Kimberley basin of northwestern Australia. Softer rocks in nonuplifted cratonic basins form broad plains rising inland to more than 500 m. In the north, such basin plains are occupied by major external river systems, for instance the Fitzroy river, but in the arid interior they are extensively sand covered and form sand-ridge deserts. These regular systems of parallel dune ridges, spaced at about 350 m and mainly between 10 and 25 m high, are more widespread in Australia than in any other continent. They describe an enormous arc, with eastward extension through the Great Victoria desert in the south and a westward growth in the Great Sandy and Gibson deserts in the north, linked by the north-trending ridges of the Simpson desert in the Interior Lowlands. They mainly occupy lowlands and result from wind-working of sandy alluvium, presumably in periods of past greater aridity in that over much of the area they are now partially stabilized, although most of them are still marked by relatively mobile crests of strikingly red sand. The dunefields of the sedimentary basins together with the stable sandplains of the shield areas cover more than 2.5 million sq km.

Landforms of the marginal basins

A discontinuous coastal lowland, generally less than 15 km wide, is formed on a series of younger marginal sedimentary basins. Depositional landforms predominate here, including mangrove and salt marsh flats in the northwest and sand dunes, including calcarenite dunes, in the west and southwest. In the south is the karstic Nullarbor plain with large cavern systems connecting to the surface in collapsed dolines.

Landforms of the Interior Lowlands

This north-south belt of lowlands, mainly below 150 m, corresponds with depressed basin structures in a tract of little-deformed weak rocks.

The north and central parts were planed, deeply weathered and duricrusted in the Australian land surface, and were subsequently warped into the lowland basins of Carpentaria and Eromanga-Surat, with centripetal patterns of drainage. Erosional landforms predominate in the outer areas and include duricrusted tablelands above undulating stony lowlands. Depositional landforms are more extensive in the lower lying inner regions of the basins and comprise floodplains, with anastomosing rivers, and dunefields. The lowest part of the Eromanga basin is occupied by a line of salt lakes, including Lake Eyre, forming the terminals of inland drainage systems. In the south, the Murray basin has been an area of continuing deposition throughout the Cainozoic era. It comprises the fluvial riverine plains in the east and the mallee dunefields in the west.

Landforms of the Eastern Uplands

The eastern margin of the continent is dominated by an arcuate belt of strong relief, mainly between 330 and 500 km wide, which extends 4 000 km from Cape York to southern Tasmania and constitutes the main watershed of Australia. The Eastern Uplands are structurally complex and include high-standing orogenic blocks and intervening younger basins. The former consist of highly folded and metamorphosed sedimentary and volcanic rocks and intrusive granite; the latter contain younger sedimentary rocks which have generally undergone little or moderate deformation. The whole belt underwent variable Cainozoic uplift, which has determined the position and elevation of the Main Divide and the eastern coastline.

Uplift was generally greater toward the south, and there is a corresponding increase in elevations southward. Summits in Queensland reach between 600 and 900 m, but through New South Wales they increase from between 1 200 and 1 500 m on the New England tableland to more than 1 800 m in the Snowy mountains. In transverse section, the coastal fall is steeper than that to the inland plains, and locally attains the dimension of a monoclinal flexure. These Kosciuskan movements and the consequent rejuvenation of drainage have determined the present relief, and notably the contrast among the interior tablelands, the plateau watershed, and the dissected coastal margin with incised valleys.

Volcanic landforms in the Eastern Uplands

Volcanic activity was associated with the Cainozoic uplift of the Eastern Uplands, with extensive outpourings of basalt. The older basalts were extruded as valley flows in areas of strong relief, as in the uplands of Victoria, or as extensive lava sheets in open country, as on the plains of southern Queensland. Some flows have been deeply weathered and laterized. Many originated as fissure eruptions, but Mount Warning in northern New South Wales is a caldera and numerous smaller craters occur elsewhere. Vulcanism persisted into the Holocene near the extremities of the Eastern Uplands in Queensland and in western Victoria. These younger basalts exhibit fresh bouldery surfaces with scoria mounds, tumuli and lava tunnels.

Quaternary geomorphology

Due to the characteristic steep coastal fall, geomorphic expression of sea level changes is generally restricted. In southeastern South Australia a series of calcareous beach ridges extends 100 km inland and attains an elevation of 75 m, but evidence of sea stands in the higher altitudinal ranges is generally fragmentary and differential land movements may be involved. In contrast, late Pleistocene shorelines closer to the present sea level are widely established. In the southeast a sea level of 5 m dated to more than 25000 BP is indicated by an inner barrier complex of sand beach ridges and dune cappings. The sands differ from those of Holocene shorelines in their strong podzolization and in the occurrence of groundwater pans of iron humate.

Coastal rivers dissected these Pleistocene forms during the subsequent regression and were drowned in turn during the following postglacial recovery of sea level. These episodes were marked by widespread invasion of aeolian sands, as calcarenites in the south and west and as siliceous sands in the southeast. Recovery of sea level was marked by the formation in southeast Australia of outer barrier beach complexes, impounding lagoons in former open embayments.

The arrangement of river terraces in coastal valleys changes from a vertical staging upstream to one of older deposits overlapped by younger near the coast. Aggradation continued with low sea levels, indicating a predominance of climatic over eustatic controls.

Climatic changes in southeastern Australia in the late Pleistocene involved depression of the orographic snowline by 600-700 m and the extension of periglacial solifluction 600-1 000 m below its present limit.

In Tasmania about 5 000 sq km were ice-covered, mainly by small ice sheets on the Central plateau, where numerous small rock basins were ice-scoured, giving the present lake-dotted surface. Outlet valley glaciers eroded deep troughs with hanging tributary valleys and lake basins such as Lake St. Clair, and left moraines on adjacent lowlands. Cirque glaciation was general in rugged western Tasmania.

On the mainland, a small glacier occupied the Snowy river valley above 1 680 m, but the most striking landforms are the cirque basins incised into the eastern lee flank of the summit ridge of the Snowy mountains.

Periglaciation occurred throughout Tasmania above 600 m and extensively in New South Wales above 1 000 m. The main forms are fossil solifluction sheets, block streams and patterned ground.

Over much of interior Australia, Pleistocene climatic changes involved alternations of wetter and drier climates superimposed on the general trend from moister conditions in the Tertiary to the present aridity.

A former extension of aridity north of its present margin is shown by the occurrence of dune ridges in parts of northwestern Australia now receiving more than 700 mm annual rainfall. Their forms are subdued and they have developed soils. Near Derby they have been transgressed by Holocene tidal sediments, showing that dune extension occurred before the full postglacial recovery of sea level. Stabilized dunes also extend south of the arid zone in the mallee of Victoria and New South Wales, where buried soils and parabolic dunes indicate three arid phases with intervening periods of soil formation.

In the riverine plains, sinuous prior channels were active in late Pleistocene and again in early Holocene time under conditions drier than at present, with an intervening arid phase marked by the deposition of sheets of windblown clay or parna. The present meandering rivers date from a subsequent amelioration of climate at around 4000 BP.

In the desert interior, undated pluvial phases are marked by high lake shorelines and by former river connections that are no longer operative, for example that between the Finke river and Lake Eyre. Suites of piedmont gravel terraces indicate fluctuations of stream capacity in the Macdonnell and Flinders ranges.

Across much of southeastern Australia fluctuations between semiarid and humid climates resulted in periodic instability of hillslopes on a regional scale due to diminution of vegetation cover and increased runoff. They were marked by the sloughing of colluvial mantles from upper hillslopes and their accretion on footslopes and as gully fills. They caused aggradation in the coastal rivers, where sequences of climatic terraces have been distinguished on the basis of altitude and pedogenensis.

PAPUA NEW GUINEA[1]

New Guinea and its islands, being situated between the stable land mass of Australia and the deep ocean basin of the Pacific, are part of the highly mobile zone of the earth's crust surrounding the Pacific ocean. Young folded and faulted mountain chains, curved chains of islands and oceanic rises — called island arcs — and recent volcanic and seismic activity are characteristic features of this circum-Pacific mobile zone. Uplift and faulting commenced in New Guinea in the Upper Oligocene to Lower Miocene period and have continued to the present. These tectonic events led to the formation of the framework of the present-day landforms. Extreme volcanic activity was associated with these earth movements, and large areas were covered by andesitic volcanic products.

The physiographic regions closely follow the main tectonic provinces. From south to north these are: the southern plains and lowlands, the central ranges or cordillera, the intermontane trough, the northern ranges, the northern coastal plains and the island chains.

Southern plains and lowlands

The southern plains and lowlands extend from the south coast to the foothills of the central ranges. They are most extensive in the Fly and Strickland river area. To the east they become progressively narrower until divided by the foothills of the central ranges into several embayments. Most of the Fly-Strickland area constitutes a relict alluvial plain which is built up of unconsolidated or poorly consolidated fluvial deposits and which has been dissected to varying degrees.

The central and eastern parts of the Papuan plains and lowlands consist of marshy coastal plains at the mouths of the main rivers merging upstream into relatively stable and well-drained alluvial plains.

Central ranges

The central ranges, the backbone of New Guinea, are the dominant physiographic province occupying nearly half of mainland Papua New Guinea. They are a complex system of ranges and upland valleys and plains and vary in width from about 50 km in east Papua to 200 km at their centre. The relief is greatest at the margins where the mountains descend steeply to the flanking lowlands.

The most widespread landforms are mountains characterized by irregular branching ridges, with a relatively widely spaced dendritic pattern of V-shaped valleys, formed on a variety of sedimentary, igneous and metamorphic rocks. The ridges have very narrow crests and long steep slopes, generally straight in the overall profile but irregular in detail. Less widespread but also very prominent are landforms which exhibit a clear structural control such as strike ranges and homoclinal and hogback ridges, having a westerly to northwesterly trend. Most of these ranges are formed on limestone or hard sandstone. Spectacular karst landforms cover large areas of the southwest of the central ranges and their foothills. Volcanic landforms are also widespread in the southeast and in the central parts of the ranges. They are mostly strato volcanoes with a typical radial drainage pattern.

Interspersed with these mountainous landforms are upland valleys which, although covering much less area, are very important for human occupation. They are mainly covered with alluvium and fan material.

Intermontane trough

The Sepik-Ramu-Markham trough or intermontane trough is a young graben extending through the whole island from Geelvink bay in West Irian to the Huon gulf in Papua New Guinea and thus separating the central from the northern ranges. It is occupied by extensive plains and lowlands as well as floodplains and swamps. Most extensive are the Sepik and lower Ramu plains, which merge and form an extensive area of swamp and poorly drained alluvial plain. The upper Ramu and Markham plains by contrast consist of relatively sharply sloping fans formed of coarse material derived from the steeply rising and tectonically very active Finisterre and Saruwaged ranges.

The northern ranges

The northern ranges, running parallel to the central ranges, consist of several individual ranges separated by structural lows. They are predominantly formed by dendritic mountain ridges and V-shaped valleys flanked by irregular foothills. On the Huon peninsula there are prominent structural limestone plateaus and sloping surfaces with some karst features.

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[1] The material for this section was supplied by Dr. E. Löffler, CSIRO, Division of Land Use Research, Canberra, A.C.T.

The northern coastal plains

The northern coastal plains form a narrow band of beach ridges and mangrove flats, alluvial plains and swamps, and coral platforms and terraces in front of the steeply rising northern ranges. In contrast to the south coast of Papua New Guinea, which is relatively stable, the north coast is rising at a considerable rate. Radiometric dating of coral terraces along the Huon peninsula have shown that these coastal areas are rising up to 3 m per thousand years.

The islands

Numerous islands are situated off the north coast of New Guinea and its easternmost tip. The Bismarck archipelago comprises all the larger islands which form an oval ring about the Bismarck sea, structurally consisting of two island arcs, the southern Bismarck island arc and the northern Bismarck island arc. The former includes New Britain and the chain of volcanic islands off the north coast of New Guinea. It is a typical island arc with a belt of active volcanoes along its concave north coast. Most of the volcanoes are active. The central and southern region of New Britain consists of rugged mountains and extensive areas of karst with raised coral terraces along the coast.

The northern Bismarck island arc consists of Bougainville and Buka Islands, New Ireland, New Hanover, the St. Matthias group and the Admiralty Islands.

New Ireland forms a long narrow northwesterly trending island with several narrow necks. The southwesterly area of the island is mountainous while the central and northwestern areas are dominated by well-developed tropical karst landforms.

New Hanover has a core of older volcanics surrounded by alluvial deposits. The original volcanic landforms have been all but destroyed.

The Admiralty Islands to the west comprise Manus Island and some very small islands grouped south of Manus. Manus is mainly hilly, but some parts are mountainous.

The D'Entrecasteux Islands and the Louisiade archipelago represent structurally an extension of the mainland. They are formed by rugged mountains and are surrounded by raised coral platforms.

Quaternary history

The climatic changes during the Pleistocene probably caused little change in the landform development in Papua New Guinea. In the mountains small glaciers developed and periglacial activity was more extensive in response to a temperature depression of some 4-5°C, and in areas of currently strongly seasonal climate a change to drier conditions seems likely. Evidence of sea level changes is abundant along the tectonically active north coast and in the Bismarck archipelago. By far the larger part of Papua New Guinea, however, remained under the influence of a humid tropical climate and has therefore been subject to the rapid weathering and denudational processes characteristic of this climatic zone.

NEW ZEALAND

New Zealand stretches some 1 600 km from north to south, and its 265 000 sq km in three main islands embrace a wide variety of landforms. Approximately half the land is steep, a fifth is hilly and less than a third is rolling or flat. The land rises from two main submarine ridges which extend northwestward to New Caledonia and New Guinea, and northeastward toward Tonga. It lies in a zone of persistent tectonic activity which has led to both stratigraphic complexity and recurring vulcanism.

The North Island has main axial ranges that trend northeast from Wellington to East Cape and rise to over 1 500 m. The ranges are composed of greywacke and argillite rocks which also form some of the hilly land south and north of Auckland. The ranges are flanked by younger sediments, mainly sandstone and mudstone with some limestone, from which have been carved the hills and narrow lowlands of the east and west coasts and much of the Auckland peninsula. In the centre of the island is a plateau formed of thick sheets of rhyolitic rocks from which rise more basic volcanoes to heights exceeding 2 500 m. Intermediate and basic igneous rocks also occur around Mount Egmont in the west and in scattered areas south and north of Auckland. Much of the central part of the island is mantled by thick deposits of volcanic ash (Pullar, 1973). Toward the south extensive loess deposits have been mapped (Cowie and Milne, 1973).

The South Island also has an axial range, which rises to 3 600 m in the Mount Cook region and has many peaks over 3 000 m. Greywackes and metamorphics predominate in the extensive areas of steep land, and erosion debris forms the parent materials of the soils of the alluvial plains and loess-covered downlands. The most extensive plains are those of Canterbury and north Otago, which consist mainly of late Pleistocene or Recent fans of greywacke gravels with a thin covering of loess. Other coastal plains, such as those in Southland, are less extensive. Intermontane basins in Canterbury are usually floored with greywacke gravels, while those among the block mountains of central Otago contain deposits of schist except where they abut Tertiary hills or the greywacke ranges to the northeast. These gravels, as on the plains, are frequently coated with thin deposits of loess (Bruce *et al.*, 1973). A more detailed account of New Zealand landforms has been written by Shaw (1959).

SOLOMON ISLANDS

The seven major island groups were all formed from pre-Tertiary or Tertiary andesitic or basaltic volcanic complexes, erupting initially beneath the sea and eventually emerging to form high rugged islands. Only one emerged volcano is currently active, a few are dormant and most are extinct. The characteristic conical landforms are evident throughout the New Georgia group, west Guadalcanal and parts of Choiseul, where uneroded lava flows and debris slopes are readily identified, but elsewhere have been eroded into systems of narrow, steep-sided high ridges. The interiors of most islands exceed 1 000 m in places, and on Guadalcanal the highest peaks reach 2 300 m (Hansell and Wall, 1975).

Surrounding the volcanic ridges on Choiseul, Malaita and Santa Isabel are extensive areas of weakly folded and faulted fine calcareous and coarse non-calcareous sediments, forming karst plateaus in places and elsewhere moderately developed cuesta and ridge systems. Similar landscapes occur in the northern areas of Guadalcanal and San Cristóbal: along the southern coasts of these two islands large-scale block faulting has created high, steep escarpments and exposed the basement volcanic complex.

Most of the larger islands have coastal areas formed, at least in part, by Pleistocene raised reef complexes, commonly backed by low foothills. The raised reefs are in the form of parallel linear terraces in the New Georgia group (Stoddart, 1969) but may also form extensive level or undulating areas at the extremities of islands such as Choiseul, Malaita, San Cristóbal and Santa Cruz. The islands of Rennell and Bellona are classic examples of raised atolls, the former containing a large lake near sea level and an unbroken karst rim almost 200 m high in places (Taylor, 1973).

Recent alluvial land is only poorly represented in the Solomon Islands. While there are abundant rivers, some large, they have rarely been able to form extensive floodplains owing to continuing tectonic instability. There are exceptions, however, the most notable area being the northern plains of Guadalcanal. This comprises 400 sq km of young fluviodeltaic sediments from several major rivers which have been slightly uplifted in places to form low terraces. Similar areas, lower, wetter and smaller, occur in southern Santa Isabel and northern San Cristóbal. Other floodplains tend to be narrow and prone to flooding, and are commonly swamp-filled in the lower courses.

The presence of modern onshore and offshore reef around many coasts has an importance out of proportion to the area covered. Reef occurs at the surface, particularly around currently stable coasts where there is no contamination of sea water by rivers. Where it does not occur, such as on the southern and northern coasts of Guadalcanal, harbours are few, and beaches may be absent.

NEW CALEDONIA

New Caledonia is a mountainous island but with few summits above 1 300 m (Mount Panié, 1 642 m). It contains a number of different physiographic units. Ultrabasic massifs occur mainly in the south and on the west coast, and have steep-sided deep valleys. The southern massif falls in the southeast to form a suspended plain (plaine des Lacs), connected to the sea by falls and cascades indicating its ancient morphology. The metamorphic massif of the northeast coast includes Mounts Panié and Colmet. It is a vast wall rising directly from the sea to the summit. The central chain of moderate elevation (400 to 1 000 m) in some places has its fossil relief conserved, but is mainly severely eroded. The plains of the west coast are a succession of alluvial plains separated by ultrabasic massifs or by foothills of the central chain.

The broken relief, combined with the intensity of the rainfall, favours intense erosion and a general youthfulness of the soils.

PACIFIC OCEAN

The large islands of the western Pacific margin — New Caledonia, New Hebrides and the Solomons — are of similar form to New Guinea, New Britain and New Ireland. They have high rugged mountains, numerous volcanoes, including some still active, and relatively small areas of lowland terraces and coastal plains. The large oceanic high islands such as those in Samoa and Hawaii have similar highlands, often rugged, with some easy lowlands and alluvial plains.

Some smaller high islands rise to heights of 1 000 m or more from areas of a few square kilometres. These may be steep to the water's edge and provide living space only on isolated narrow beaches.

Coral islands are mainly atolls in which a reef with small patches of land encloses large shallow lagoons. The land is formed of coral debris and sand thrown up by waves on top of the reef. These areas may cover only a few hectares and seldom exceed 5 or 6 m in height. There may be moist hollows in which vegetation is more vigorous. In these hollows soils may occur with sufficient organic matter to allow crop growth. Otherwise crops are grown in compost pits or in soil transported in from volcanic islands (Bruce, 1972). Raised coral islands are less common. In these, coral formation has been followed by uplift. The islands often have the form of a shallow basin with a higher encircling rim. The surface is very rough with uneven pinnacles of coral jutting profusely up from the coral bases as in a lagoon floor. Plants grow in pockets of soil among the pinnacles. An example, Niue, has been described by Wright and van Westerndorp (1965).

LITHOLOGY

AUSTRALIA[1]

The composition and microstructure of parent rocks determine to some extent the nature and rate of rock weathering and thus, finally, the class of soil. Rocks and structures such as folds and faults affect weathering indirectly by determining rock exposure, and to a small degree the physical nature of the rock. Structure (and rock type) can also influence the location of hills, valleys and lakes, for example, and thus indirectly the nature of the soil within these areas.

The intensity and duration of the structure-forming process during the Cainozoic have influenced the development of the present-day landscape and hence weathering and soil formation. The Australian continent was relatively stable during this time, and movements were restricted to vertical faulting and warping. The present landscape generally consists of land surfaces formed early in the Cainozoic and subsequently dissected to varying degrees. Many Precambrian areas have been stable for a much longer period. The surfaces carry weathering profiles in some places to depths greater than 50 m.

However, the distribution and types of rock exposed to soil-forming processes have been determined by the whole geological history of the continent. Briefly, the Australian continent consists of three major elements:

1. The Precambrian area which occupies the western two thirds of the continent, and which is extensively overlain by Phanerozoic basinal deposits ranging in age from Cambrian to Tertiary. The Precambrian consists of Archaean blocks and Proterozoic orogenic belts and platform cover. The most easterly Precambrian units of this element are at about longitude 141°E, but Precambrian is also exposed in northern Queensland and Tasmania.

2. The eastern Australian orogenic province, which generally parallels the eastern coastline from Cape York to southern Tasmania and which is a complex of orogenic belts and basins, ranges in age from Precambrian to Mesozoic. Tertiary and Quaternary basalt sheets occur widely through the area and some Tertiary basin sediments have accumulated in parts of Queensland, Victoria and Tasmania.

3. A belt of Upper Palaeozoic to Tertiary (but largely Mesozoic) basins which separate the western Precambrian area from the eastern Australian orogenic province.

The geology of the Australian continent may be described in terms of the tectonic domains used on the 1 : 5 000 000 scale Tectonic Map of Australia and New Guinea (Geological Society of Australia, 1971). The map shows three main types of tectonic domains based on style of sedimentation, igneous activity, deformation and metamorphism: orogenic domains, transitional domains and platform cover domains (sedimentary basins).

Orogenic domains are characterized by geosynclinal sediments, widespread and varied volcanic and plutonic rocks, strong deformation, and widespread and intense metamorphism.

Transitional domains are intermediate in style and time and are characterized by molasse-type sediments, abundant volcanic and plutonic rocks, moderate deformation and rare metamorphism.

Platform cover domains are characterized by widely distributed and thin marine and terrestrial sediments, rare plutons and associated basalt sheets. Deformation is mild and metamorphism absent.

Orogenic and transitional domains broadly related in style and time can be grouped as an orogenic province, four of which have been recognized (Geological Society of Australia, 1971): West Australian, North Australian, Central Australian and East Australian. In addition, two groups, Late Precambrian Domains and Unassigned Precambrian Metamorphic Complexes, cater for miscellaneous domains which do not fit into the main groups.

Orogenic provinces

The West Australian Orogenic Province consists of deformed geosynclines and metamorphic complexes, and forms basement to the West Australian Platform Cover.

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[1] The material for this section was supplied by Mrs. P.E. Simpson and W.D. Palfreyman, Bureau of Mineral Resources, Department of National Development, Canberra, A.C.T.

The North Australian Orogenic Province consists of deformed sedimentary sequences and forms basement to the North Australian Platform Cover.

The Central Australian Orogenic Province consists mainly of metamorphic complexes. It forms basement to the Central Australian Platform Cover.

The Late Precambrian Domains consist of metamorphics and granites in the southwest of Western Australia and in Tasmania.

The East Australian Orogenic Province consists of a number of deformed geosynclines and forms basement to the Trans-Australian Platform Cover.

The Unassigned Precambrian Metamorphic Complexes occur in Northern Territory and Queensland.

Platform covers

The platform cover domains have been grouped similarly into four platform covers:

The West Australian Platform Cover consists of Lower Proterozoic sediments in the Hamersley basin in the northwest of Western Australia.

The North Australian Platform Cover is formed in four basins, mainly in Northern Territory and in the extreme northeast of Western Australia. Common sandstone outcrops give a dissected landscape with a relief of up to 300 m.

The Central Australian Platform Cover is very extensive in Western and South Australia and Northern Territory, forming land of generally low relief. Ridges seldom rise more than 200 m above the surrounding surfaces.

The Trans-Australian Platform Cover extends from Cape York to Tasmania, and also occurs in the south and west of Western Australia. The basins, which include the 800 000-sq km Eromanga basin, are mainly flat or gently rolling with occasional mesas or low plateaus.

The rock types are too complex to describe in detail. A broad outline is given in Figure 12. For detailed information publications of the Australian Bureau of Mineral Resources, Geology and Geophysics should be consulted. One of these is the geological map at a scale of 1 : 5 000 000 of Australia and Oceania, published as part of the Geological Map of the World (Australia, Bureau of Mineral Resources, Geology and Geophysics, 1965).

The relation of soil to rock type is shown for each soil association in Chapter 5. The broad pattern of soils reflects the major structural elements of the continent. On the Precambrian shield the flat plateau surface cuts across rocks and structures of many ages. The soils include Lithosols, Arenosols, Regosols, Xerosols and Yermosols. Planosols and Luvisols are also extensive, and Solonetz and Solonchaks occur in some areas.

The surface of the east central basins, on soft horizontal sedimentary strata, contrasts with the peneplain of the shield. The soils are mainly Regosols, Xerosols, Yermosols, Vertisols and Solonetz.

The eastern orogenic province is a complex of folded warped and broken sediments uplifted into ridges and plateaus and extensively intruded by granite and overlain by volcanics. The soils form a complex pattern in which Planosols, Luvisols and Solonetz are extensive. Histosols, Ferralsols, Acrisols and Cambisols are the most widespread of the other soils.

PAPUA NEW GUINEA

Northern and eastern Papua New Guinea form part of the Melanesian structural belt. The area is characterized by sigmoidal structural trends, volcanic and seismic activity, and deep ocean trenches. The varied and complex landforms are closely related to structure and geology. The high fold mountains with intensely dissected fault scarps, the raised coral reefs and drowned littorals, and the prevalence of volcanic landforms are all evidence of the geological instability (Brown and Pain, 1970).

The main rock types are Tertiary limestone, volcanics, sandstone and siltstone, and Quaternary alluvium and volcanics. Mesozoic sedimentaries and metamorphics occur in the Central Cordillera and rocks dating back to Upper Palaeozoic have been discovered (Renwick, 1970).

NEW ZEALAND

The distribution of a wide variety of New Zealand rocks, representing almost every geological period since the Precambrian, has been summarized by Shaw (1959) and Grindley *et al.* (1959). The oldest rocks (Precambrian and Lower Paleozoic), including diorite, gneiss and granite, and strongly folded, indurated conglomerates, sandstones, shales and marbles, are found in a belt from Stewart Island and Fiordland up the west of the South Island to Nelson.

Mesozoic and Upper Paleozoic greywackes, argillites and schists form the core of the country and make up the main axial and some other ranges. Tertiary and early Pleistocene rocks consist of sandstones, mudstones, siltstones, limestones and conglomerates. They flank the main ranges, and are particularly widespread in the North Island.

Basic and intermediate volcanic rocks, ranging from Mesozoic to Recent in age, occur in numerous areas in the north and west of the North Island and in some eastern areas of the South Island. They also occur round the central North Island volcanoes.

Acidic volcanic rocks are confined to the central rhyolitic plateau in the North Island and to some patches further north.

Drifts deposits, which are particularly important in soil formation, include glacial and periglacial materials of the Ice Age, volcanic ash, coastal sand drifts and alluvium. Loess and solifluction deposits are extensive in the South Island and southern North Island (Bruce *et al.*, 1973; Cowie and Milne, 1973). Volcanic ash mantles much of the central North Island. The many beds have been extensively studied and their distribution and composition determined (Pullar, 1973). Sand drifts border many coasts, particularly the west coast of the North Island. Alluvium occupies floodplains, terraces and plains in many areas. Its texture and composition are variable, depending on the nature of the adjacent country. Peat is also widespread, although the total area is relatively small.

SOLOMON ISLANDS

The geology of various areas of the Solomon Islands is described in volumes of the British Solomon Islands Geological Record, and is best summarized by Coleman (1970).

The islands form a double chain on the northern limb of the large bathymetric high termed the Melanesian Re-entrant, closed in the northwest by Bougainville and in the southeast by San Cristóbal. They lie *en echelon* as a result of major shears along the axis of an active primary fracture zone on which the islands lie, and extensive faulting has resulted in anticlinal horsts and intervening basins throughout the area.

The islands are geologically youthful, with few rocks predating the Tertiary and none recognized older than the Lower Cretaceous. On the basis of structure and lithology Coleman (1966) has described three provinces, the Volcanic, Central and Pacific provinces. The Volcanic province occupies a compact area in the west and contains the whole of the New Georgia and Shortland groups, the Russell islands and western Guadalcanal, and almost all the active and recent volcanoes are found within it. The islands are formed essentially of cone and debris fields extended and linked by derived sediments and encircled by fringing and barrier reefs. Most lavas are olivine basalts ranging to hornblende andesites and there is much pyroclastic material. Their age ranges from Upper Miocene to Recent.

The Central province includes San Cristóbal, most of Guadalcanal and parts of Santa Isabel and Choiseul. It has a Mesozoic basal complex of chloritic and amphibolitic schists, and less altered basic lavas which outcrop in isolated areas. Intruded into and extruded over these rocks are Upper Eocene-Oligocene dikes, lavas, agglomerates and pyroclastics of predominantly basaltic but locally andesitic composition, and together possibly exceeding 1 000 m in thickness. Overlying these are early Miocene to Recent reefal sediments, pyroclastics and sediments derived from both these and older basal complex rocks. They are characteristically quartz-poor and commonly lime-rich, being deposited in fault-bounded subsiding troughs so that up to 5 000 m of sediments have accumulated in places.

The structure of the Central province is one of blocks and troughs separated by three-directional faulting. Faulting has been intense, and along major fractures large blocks have foundered off the southern coasts of Guadalcanal and San Cristóbal, for example. The boundary between the Central and Pacific provinces is marked by a major fracture system which has acted as a locus for the emplacement of serpentinites beginning in the Oligocene and extending locally into the Quaternary.

The Pacific province encompasses Malaita, where its features are best developed, parts of northwestern Choiseul and Santa Isabel. It comprises basal sequences of highly basic submarine lavas, overlain concordantly but irregularly by Upper Cretaceous limestones, then calcareous, mainly fine-grained sediments, together more than 1 000 m thick. The whole sequence has been faulted, and folded *en echelon* with a northwestern trend. Coarser, less limey sediments with a higher terrigenous component occupy parts of Santa Isabel, Choiseul and the northern coast of San Cristóbal, and are considered marginal to the province.

Young, pan-provincial sediments occupy the fringes of many islands. These range from raised Pleistocene reef complexes, Recent fluvial, deltaic and estuarine strata and localized veneers of organic accumulations in major valleys.

NEW CALEDONIA

A great variety of rocks form the basement of the island. Sedimentary rocks include sandstone, more or less schistose pelites, limestones, phtanites, siliceous formations, and carbonaceous greywackes; volcanic rocks include acidic (granodiorites, rhyolites, diorites), basic (basalts, gabbros), and ultrabasic (peridotites, serpentinites) forms, and metamorphic rocks include schists, micaschists, gneiss, and glaucophanites.

These rocks are present in complex patterns and react diversely to weathering. Texture, schistosity and chemical composition are among the elements that strongly influence pedogenesis.

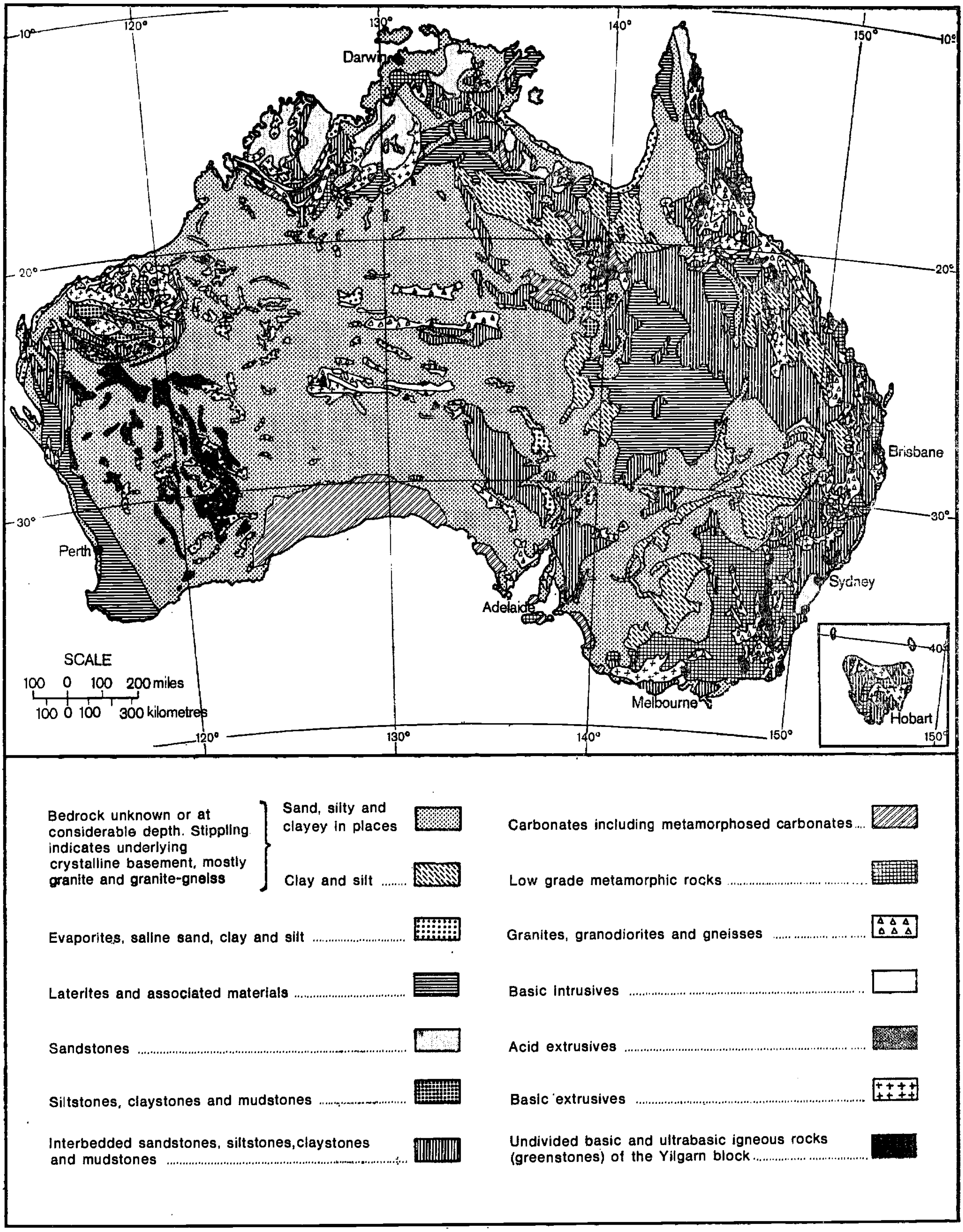

Figure 12. Distribution of main rock types in Australia

PACIFIC OCEAN

The islands of the Pacific ocean may be considered under three headings: complex high, oceanic high and coral.

Complex high islands

These islands are the projecting crests of folds in the earth's crust found mainly on the ocean margins. They contain siallitic rocks, such as granite, and sedimentary rocks derived from adjacent land masses, so they are closely associated with the continents. New Guinea and the islands of the Bismarck archipelago are examples. South of these the Solomon islands, New Hebrides and New Caledonia all have continental features. To the north the Philippines, Japan and the Aleutians provide further examples.

A boundary between the continental and oceanic islands can be seen in the Caroline Islands between Yap and Truk. To the west toward Asia the islands are exposures of folds similar to the greater arcs nearer the continent, and the rocks are diverse. To the east the islands are volcanic, rising directly from the ocean floor.

Oceanic high islands

These islands are all volcanic, mainly basaltic or, in the southwest, andesitic. They are the peaks of great domes of basaltic lava extruded from the sea bed 4 000 m or more below the surface. Active since the Miocene some of these volcanic centres have built mountains of immense size. Mauna Loa in Hawaii, for example, standing some 9 000 m above the sea floor, is the largest mountain mass in the world and is still actively growing. In the 1950 eruption over 500 000 cu m of lava were erupted in three weeks. Groups of these volcanoes have produced substantial land masses. Hawaii Island covers more than 10 000 sq km. However, the islands are typically less than 1 500 m in altitude and 1 000 sq km in area.

Coral islands

There are many thousands of coral islands in the Pacific, ranging from small islets and sand banks to great barrier reefs hundreds of kilometres long, extensive raised coral islands, and atolls enclosing up to 2 000 sq km of ocean. These coral formations may also be very thick. A borehole at Bikini Atoll in the Marshall Islands was still in coral at 780 m, and another at Eniwetok in the same group had to be sunk to 1 400 m before olivine basalt was reached. It seems probable that coral started to grow in shallow waters as reefs fringing volcanic islands, and then continued to grow near the ocean surface as the volcano subsided. Such subsidence has clearly been widespread, but uplift has also occurred as is evidenced by raised coral islands. These more or less circular islands, flat on top apart from a raised rim, are usually less than 70 m high and 25 sq km in area. Larger ones do occur, such as Niue which covers 250 sq km.

Coral limestone is exceptionally pure, forming surfaces of sand or rubble over unevenly weathered hard rock. Soils are dry and not highly productive unless they are built up with organic matter or have received accessions of volcanic ash or other mineral material.

A feature of many of these islands is the presence of phosphate deposits. Some, such as those on Mauru and Ocean, are of high quality and great size. Others show only as high phosphate levels in the soil.

Other forms

Although islands of complex, oceanic or coral types are common, mixed forms are also widespread. The complex islands usually show extensive volcanism, and often have fringing coral reefs. The high oceanic islands frequently have associated coral formations. The coral islands are, of course, built on a volcanic base, but this may be deeply buried. Volcanic influences are mainly restricted to areas affected by air-fall ash or water-borne pumice. Soil associations on many islands therefore include soils from a diversity of parent materials.

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5. THE SOILS OF AUSTRALASIA AND THE PACIFIC

The legend of the Soil Map of Australasia and the Pacific consists of 480 map units in different soil associations, each of which is composed of one or more soils occupying characteristic positions in the landscape. The sequence of their occurrence is related mainly to topography, geomorphology and lithology.

Each soil association is characterized by the dominant soil — the soil with the widest extension — and by associated soils and inclusions which occur to a lesser extent. A total of 66 different dominant soils are indicated on the map.

For convenience and brevity the soil associations are listed in Table 10. The following information is given:

Map symbol. The map symbol of the dominant soil, followed by the number specifying the composition of the soil association, a second number indicating the textural class of the dominant soil, and a small letter indicating the slope class of the association. Textural class numbers are: (1) coarse, (2) medium, (3) fine. Slope class letters are (a) level to undulating, (b) rolling to hilly, (c) steeply dissected to mountainous.

Associated soils. Subdominant soils with an extension of more than 20 percent of the mapping unit.

Inclusions. Inclusions of important soils occupying less than 20 percent of the mapping unit. Additional soil inclusions which may be significant in the mapping unit but are of small areal extent have sometimes been added in brackets.

Phase. Phases related to the presence of indurated layers (fragipan, duripan, petric, petrocalcic), hard rock (lithic), stones (stony), salinity (saline) and alkalinity (sodic).

Extension. An estimate of the area of the unit in thousands of hectares.

Climate. Climatic data vary in form according to relevant and available information. Notes on the figures and symbols used are given below.

Occurrence. Countries of occurrence (for Australia the State or broader geographical region, such as "southern" or "eastern," is also given).

Vegetation. The predominant natural vegetation of the area, with an indication of present or potential land use.

Lithology. The predominant lithology of the area, with an indication of the landform. The range of altitude is also given where available.

It should be emphasized again that the data in this table are of a very general nature, and any conclusions drawn on the relationships between soils and soil-forming factors must be considered provisional.

Climatic data

The climatic data used are varied. For Australia, maps of median annual rainfalls and average annual temperatures are included in Chapter 4. In Table 10 an indication of seasonal rainfall is given. The seasonal rainfall classification, prepared by the Commonwealth Bureau of Meteorology, Melbourne, is based on annual rainfall, seasonal incidence and altitude. The seasonal incidence is determined from the ratio (greater:lesser) of the median rainfalls: November-April (summer) and May-October (winter). The terms are defined in the legend to Figure 3. The numbers in Table 10 indicate the climatic regions of Papadakis, also described in Chapter 4.

In Papua New Guinea, as indicated in Chapter 4, temperatures are high and uniform, the main cause of variation being altitude. Rainfalls vary widely, however, and in some areas seasonality is important. Mean annual rainfall and seasonality have therefore been noted in the table.

For other areas, mean annual rainfall and mean annual temperatures are given where available. On the larger islands local seasonal differences occur, but at this mapping scale it has not usually been possible to separate these.

Soil formation

The environment of Australasia and the Pacific is extremely varied. This applies to climate, vegetation, physiography and lithology, and as a consequence soils are also varied. Of the 106 soils recognized in the Soil Map of the World, 77 are found in this region in sufficient area to be represented in the soil associations, and 66 are dominant in associations.

All the soil-forming factors of climate, topography, parent material, vegetation and time exert their influence, and in places one or the other dominates the soil pattern. More commonly, however, combinations of factors are involved. The impact of man is increasingly being impressed on the soils, and soil degradation from destruction of the indigenous vegetation, from widespread cultivation and from other forms of " development " is obvious in many areas.

Climate is the overriding influence in the region. Most of Australia is under desertic regimes, with Regosols, Arenosols, Yermosols and Xerosols dominant, and Solonetz, Vertisols and Calcic Luvisols widespread. In the tropical and subtropical islands rainfalls and temperatures are unusually high and leaching and weathering intense. Soils such as Acrisols and Ferralsols occur on stable sites, as in the Papua New Guinea lowlands and northern New Zealand.

Topography becomes the main influence on soil pattern as slopes increase into slope class c — steeply dissected to mountainous. Here active soil renewal slows the zonal processes and Cambisols are formed, with, in places, Lithosols and Regosols. Examples are found in the Papua New Guinea mountains, in the high islands, and in southern and central New Zealand.

Parent materials in the region are extremely diverse, and in many areas have a strong influence on the soil pattern. Some examples are the Calcic Regosols on coral sand on the oceanic low islands, the Andosols on volcanic ash on the New Zealand volcanic plateau, the Acric Ferralsols on ultrabasic rocks in New Caledonia, and the Rendzinas on limestone in the Papua New Guinea highlands and the high islands of the western Pacific.

Vegetation is commonly so closely related to other soil-forming factors such as climate that its distinctive contribution to soil formation is obscured. An example is recorded from northern New Zealand, where the kauri tree is notable for its Podzol-forming influence on soils.

Time-dominated soils are best demonstrated where time has been short. Regosols near active volcanoes and Fluvisols on river flats are examples widespread in the region. At the other end of the scale are soils such as Arenosols, Yermosols and Xerosols in Australia on surfaces that have been stable for extremely long periods.

Finally, some areas are notable for the complex array of soils developed under the influence of interacting soil-forming factors. The eastern uplands of Australia are a good example. Here 21 of the 26 orders of the Soil Map of the World legend are found in an area in which all the factors vary. Differences in the complex high islands of the western Pacific, mainly in parent material, topography and time, have also produced large numbers of soils in relatively small areas.

While most of the broad relationships noted here are clearly defined, there is still much work to be done before the soil pattern of the region, in all its diversity and complexity, can be fully understood.

Major soil regions

To aid understanding of the soil geography, the region has been divided into broad structural and ecological regions, each of which has a characteristic pattern of soil distribution. These regions will be briefly discussed.

AUSTRALIAN WESTERN PLATEAU

The Australian Western Plateau occupies some two thirds of the continent — all of Western Australia, most of Northern Territory, and large parts of the west and south of South Australia. It is a stable Precambrian shield which includes areas with exposed crystalline basement, more extensive areas of " platform cover " where sediments have been deposited in depressions in the basement, and narrow coastal lowlands. Most of the shield is a plateau eroded through long ages to a low flat or undulating surface that is usually less than 300 m above sea level. Even the deeply weathered mountain ranges in the centre seldom exceed 600 m. The climate is dominated by extreme aridity, most of the region receiving an average of less than 250 mm rain a year. In the extreme southeast and southwest this is exceeded and small areas, particularly in the southwest, receive more than 500 mm. In the north large areas receive substantial rain, but as most of this falls in the short monsoon period in summer its effectiveness is low. The natural vegetation broadly follows the rainfall pattern, with sparse grasses and salt-tolerant plants in the driest areas, dwarf *Acacia* or *Eucalyptus* scrub where the rainfall is a little higher, merging into savanna and open *Eucalyptus* forest at rainfalls of about 500 mm.

The soil pattern is related to the environment. It is dominated by soils of the deserts — Arenosols, Regosols, Yermosols and Xerosols. The main soil units are Ferralic Arenosols, Dystric Regosols, Luvic Yermosols and Calcic Xerosols, but others may be locally extensive. These soils occupy more than half the continent.

On the desert margins other groups are associated with the desert soils. In the northwest Calcic Luvisols and Orthic Solonetz cover large areas, and in the southwest equally large areas are dominated by Solodic Planosols and Orthic Solonetz. These soils commonly have a light-textured moderately leached A horizon over the argillic B horizon. In the north the desert soils persist to the coast, but large areas of Lithosols and Chromic Vertisols also occur, as well as many other soils as the rainfall increases.

The narrow strip of coastal soils is particularly diverse. In the west, Regosols, Podzols, Acrisols and Solonchaks have been mapped while in the north Ferralsols, Nitosols, Solonchaks, Solonetz, Vertisols, Acrisols, Gleysols and Planosols all occur, together with Arenosols, Lithosols and Regosols.

AUSTRALIAN INTERIOR LOWLANDS

East of the Western Plateau, and separating it from the Eastern Uplands, is a broad depression running from the Gulf of Carpentaria in the north to western Victoria in the south. The depression consists of shallow basins, generally below 150 m in altitude, mantled with soft horizontal sedimentary strata. The landforms on the outer part of the basin are erosional, with duricrusted mesas and tablelands rising above undulating stony lowlands. In the lower central areas landforms tend to be depositional with extensive floodplains and dunefields. The climate is mainly arid, with mean rainfalls of little more than 100 mm in the centre, increasing to over 500 mm on the southern and eastern margins and to over 1 000 mm in the far north. The natural vegetation is similar to that of the Western Plateau with sparse grasses in the dry areas ranging through scrub and savanna to open *Eucalyptus* forest where rainfalls are about 500 mm.

The soils of the Carpentaria lowlands and the central basins are mainly Dystric Regosols, Luvic Yermosols, Orthic Solonetz and Chromic Vertisols. Duripan, petrocalcic and sodic phases occur widely and Calcic Luvisols are commonly associated with the Vertisols. On Cape York peninsula the soils reflect the much higher rainfalls, and include large tracts of Gleyic Acrisols and Xanthic Ferralsols.

In the southern basin — the Murray lowlands — the soils are principally Calcic Xerosols in the driest areas, with Chromic Vertisols, Calcic Luvisols and Orthic Solonetz dominant to the east, and a more diverse array — including Planosols, Vertisols, Podzols, Solonetz and Luvisols — occupying the south where the rainfall may in places exceed 700 mm.

AUSTRALIAN EASTERN UPLANDS

The Eastern Uplands, bounded by the Interior Lowlands in the west and the Pacific ocean in the east, extend as a low mountain chain from Cape York to Tasmania. Structurally it is a complex of orogenic belts and basins, with ages ranging from Precambrian to Mesozoic. The orogenic belts are folded, warped and broken sediments of the Tasman geosyncline, raised into ridges and plateaus about 600 m high in the north and rising to 1 500 m in the New England tableland, and to over 2 000 m in the highest part of the Snowy mountains in southern New South Wales. The basins are younger than the orogenic belts and often contain sedimentary rocks with little deformation. Extensive flows of basalt lava accompanied the formation of the uplands and some extensive lava sheets occur in New South Wales and southern Queensland. The climate of the east coast contrasts strongly with that of the interior of the continent. Rainfall is well distributed and usually exceeds 1 000 mm a year. In a few places it reaches 2 500 mm. In the north, where temperatures are higher, rainfall effectiveness is lower and land use is correspondingly restricted. The natural vegetation roughly parallels the rainfall pattern, with tropical rain forest in parts of the north and *Eucalyptus* forest where the rainfall is lower. In the wetter parts of Tasmania extensive forests of southern beech (*Nothofagus*) are found.

The soils, as would be expected from the greater range of soil-forming factors, are much more varied than in the arid interior of the continent. Depending on topography, parent material, climate, vegetation and time, soils of 21 of the 26 main units of the Soil Map of the World legend occur in this region. None of the soils dominate the pattern as do the desert soils in the other regions, but Planosols, Luvisols and Solonetz are probably the most extensive, with Nitosols, Ferralsols, Acrisols and Cambisols also widespread.

PAPUA NEW GUINEA LOWLANDS

The Papua New Guinea lowlands occupy a vast area of alluvial plains, swamps and coastal plains around the Gulf of Papua and west to the border with Irian Barat. The swamps of the Sepik in the fault trough between the Central Cordillera and the northern mountain chain are of comparable size, and further areas occur around the southeast coast.

The most elevated parts of the southern area reach 400 m altitude almost 400 km from the coast, and consist of dissected plains and fans on deeply weathered Pleistocene sediments. The climate is hot and moist with mean annual rainfalls ranging from

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Af53-2c	Dd	Rd Po	Stony	206	800-1 800 mm: 23°C	New Caledonia	Niaouli savanna: grazing natural pasture	Acidic rocks, phtanite, schist, sandstone, rhyolite: deeply dissected: 0-400 m
Af54-3c	Rd Bd	I		411	2 000-3 500 mm: moderately to markedly seasonal	Papua New Guinea	Lowland rain forest: suitable for tree crops if not too dissected	Andesitic agglomerate tuff and lava: steep lands: mainly 0-1 000 m
Af55-3b	Bf Ap	Bd		3 310	3 000->5 000 mm; moderately seasonal and nonseasonal-wet	Papua New Guinea	Lowland rain forest	Plains and fans of deeply weathered Pleistocene sediments: hill lands: 40-120 m
Ag7-2a	J Kh	Ah Ao Qf		2 270	Summer dominant-medium: 1.42, 1.485. 1.533, 1.9. 4.1, 4.3. 7.1	Australia: eastern	Woodlands. native pastures: improved in south for dairying	Alluvium and colluvium from acid igneous rocks, cherts. shales. etc.:plains
Ag8:2a	P Lf	Ws Wd So	Stony (Lf)[1]	199	Winter dominant-high: 6.1. 6.21	Australia: western	Forest: now some improved pastures	Alluvium and colluvium from sedimentary and laterized rocks: plains often underlain with hard block laterite
Ag9-2a	Ao Fr	Fx P Qa		2 891	Summer dominant-medium: 1.244. 1.4. 1.483. 1.484. 1.485, 1.5. 4.2. 4.4	Australia: Queensland	Heaths. now grazing	Alluvium and colluvium from sedimentary and laterized rocks: plains
Ag10-2b	Ah Ws	Wd		30	Summer dominant-medium: 1.4	Australia: Queensland	Grasslands. native pastures: some improved. some sugarcane	Alluvium: flat to undulating with low hills
Ag11-2a	P Vp	Wd Ws		245	Summer-high to medium: 4.1	Australia: eastern	Forests: now sown pastures	Alluvium: plains
Ag12-2b	Be Bd	Hh	Fragipan	355	800 mm: 11°C: 5.46	New Zealand: South Island	Lowland short tussock grassland: non intensive sheep farming. cash cropping and semiextensive sheep farming	Greywacke loess: down and terrace lands: 0-500 m
Ag13-2b	Bd		Fragipan	577	900: 10°C: 7.21. 7.81	New Zealand: South Island	Lowland tall tussock grassland: podocarp-mixed hardwood forest	Schist and greywacke loess: down and terrace lands: 0-300 m
Ag14-2ab	Jd Bh Bd		Fragipan	449	1 100 mm: 9°C: 7.81	New Zealand: South Island	Lowland tall tussock grassland: now intensive sheep farming and dairying	Greywacke loess. alluvium etc.: down and terrace lands: 0-300 m
Ah1-3a				43	1 400 mm: 14°C: 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest. scrub and fern: now dairying and intensive sheep farming	Volcanic ash: down lands: 0-200 m
Ah13-2a	Vc			172	Summer dominant-low; 1.5. 3.1	Australia: Northern Territory	Woodlands: now grazed	Mudstones and siltstones: plains
Ah14-2a	Vc Ao			209	Summer dominant-medium: 1.4. 1.483	Australia: Queensland	Woodlands. native pastures: now grazed	Alluvium: plains
Ah15-2b	Nd Hl	Ag		86	Summer dominant-medium-high: 1.244	Australia: Queensland	Rain forest: now some pastures and sugarcane	Shales. phyllites. feldspathic sandstones. granites: hilly
Ah16-2/3b	Nd Ao	Ag Hl Fr		861	Winter-high. summer-medium. summer-high, summer dominant-high: 1.483, 4.1. 4.44. 7.1. 7.23. 7.24	Australia: eastern Tasmania	Forests: now some improved pastures. crops, forestry	Shales. phyllites. tillites. feldspathic sandstones, basalts. tuffs: hilly. some rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ah17-2/3c	I R	Be P Qa		894	Winter-high, summer-medium, uniform-high; 1.244, 4.1, 5.7, 7.23, 7.8	Australia: eastern Tasmania	Forests; now some improved pastures	Shales, phyllites, tillites, feldspathic sandstones, basalts, tuffs; mountainous with rock outcrops
Ah18-2a	Ag Wh	Ws Wd		96	Summer dominant-medium; 1.484	Australia: Queensland	Woodlands, native pastures; some now improved, some sugarcane	Alluvium; plains
Ah19-3b	Ao	Be	Stony (Be)[1]	33	1 100 mm; 14°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest with kauri; now scrub and extensive sheep farming	Andesitic basalt, claystone; hill lands; 0-300 m
Ah20-3c	Be Ag	Pp	Stony (Be)[1]	180	1 500 mm; 14°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now forest, semiextensive sheep farming	Andesitic basalt; steep and mountainous lands, hill lands; 0-800 m
Ah21-3c	Be		Stony (Be)[1]	26	1 500 mm; 13°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now forest	Andesite; hill lands; 0-400 m
Ah22-3c	Bd Lg	O I Ge		845	2 500-4 000 mm; moderately seasonal highland climate; wet	Papua New Guinea	Lower montane forest; some tree and arable crops and grazing on flat to rolling land	Greywacke, siltstone, sandstone mountainous; 1 500-3 000 m
Ah23-3c	Od Th	I			2 500->5 000 mm; moderately seasonal and nonseasonal; wet climate	Papua New Guinea	Lower montane forest, lowland rain forest; some tree and arable crops and grazing on flat to rolling land	Pleistocene volcanic ash; mountainous; mainly 1 000-3 000 m
Ah24-3ab	Hh Vp	Gm		46	800-2 200 mm; 21-23°C	Hawaii: Oahu	Shrubs, grassland;now pasture, truck crops, sugarcane, etc.	Basic igneous rocks, coral limestone; coastal plain, fans, terraces and uplands, 0-450 m
Ao1-3c				165	1 600 mm; 16°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now semiextensive to intensive sheep farming, dairying, forest	Sandstone, greywacke; hill lands; 0-300 m
Ao91-1/2a	R Ws	So	Petrocalcic (So)[1]	83	Summer dominant-medium; 4.43	Australia: Queensland	Woodlands; now sugarcane	Alluvium; plains
Ao92-1/2b	Ag Ah	Fr Fx Wd		398	Summer dominant-high; 1.143, 1.4	Australia: Queensland	Heaths; now grazed	Alluvium and colluvium from lateritic areas; undulating to hilly with rock outcrops
Ao93-1/2a	Fx Yl	I R So		368	Summer dominant-medium; 1.5, 1.916	Australia: Northern Territory	Woodlands; now grazed	Sediments from lateritic materials, sandstones, siltstones, limestones and shales; plains with some rock outcrop
Ao94-1/2a	Ag Fx	Fr Ws Wd	Petrocalcic (So)[1]	812	Summer dominant-medium, summer dominant-high; 1.4, 1.485, 1.9, 4.4	Australia: Queensland	Heaths; now some improved pastures	Alluvium and colluvium, mainly from sandstones; plains
Ao95-1/2a	Vc			576	Summer dominant-medium; 1.9	Australia: Northern Territory	Grasslands; now grazed	Alluvium probably from sandstones; plains
Ao96-1/2b	Ag Ah	Fr Fx P		601	Uniform-high; 1.221, 4.1, 4.4, 4.51, 5.3	Australia; eastern	Heaths, woodlands; now some improved pasture, horticulture, specialty crops	Alluvium and colluvium mainly from sandstones; hilly to steep, some rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ao97-1c	Fx P	Ws So Lc		1 802	Summer-medium, uniform-medium, uniform-high; 5.3, 5.4, 5.43, 5.45, 5.7, 5.77, 6.53, 7.8	Australia: eastern	Woodlands, forests; now some improved pastures, horticultural and specialty crops	Colluvium, mainly from sandstones; mountainous with rock outcrops
Ao98-3c	Ag Ah	Gh		792	1 500 mm; 14°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest, scrub and fern; now semi-intensive sheep and dairy farming	Claystone, mudstone, sandstone, greywacke, etc.; hill and down lands, bottom lands; 0-500 m
Ao99-3bc		Ah		208	1 300 mm; 14°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now semi-intensive sheep farming, forestry	Greywacke, sandstone; hill and steep lands; 0-600 m
Ao100-2bc	Bd	Be		192	1 300 mm; 12°C; 7.12	New Zealand: South Island	Beech and beech-podocarp. forest, some scrub and fern; now semiextensive sheep farming, exotic forestry, fruit and cropping	Weathered conglomerate alluvium; hill lands; 0-600 m
Ap27-2a	Ag	Bf J Fo Hg		2 835	1 500-3 000 mm; markedly seasonal	Papua New Guinea	Savanna, swamp, woodland, grassland; suitable for pastures and rice near coast, inundated in wet season	Strongly weathered Pleistocene fluviatile sediments; plains; 0-50 m
Bc15-3bc	Be	I	Stony	24	2 000-3 000 mm; 26°C; moderate dry season	Fiji: Moala, Matuku, Totoya	Forest, fern and grass; now subsistence cropping, coconuts	Basalt, some andesite; volcanic islands; 0-500 m
Bc29-2c	I R	Od Bh		1 159	Alpine, winter-medium, uniform-medium; 6.5, 6.511, 7.23, 7.24, 7.8, 10.5	Australia: Tasmania	Woodlands, forests, heaths, alpine communities; undeveloped	Granites, gneisses, basalts, dolerite, metamorphosed sediments etc.; mountainous with rock outcrops
Bc30-3c	Fo G	N R		11	4 000 mm; 23°C	Solomon Islands: Shortland	Lowland forest; shifting cultivation for food crops, small coconut groves	Tertiary sediments derived from volcanic sources, and associated poorly drained recent sediments; dissected ridges, cuestas and freshwater swamps; 0-200 m
Bc31-3c	Be R	I Fo	Stony	57	3 000-5 000 mm; 23-25°C	Solomon Islands: Vella Lavella, Choiseul	Lowland forest; shifting cultivation for food crops	Tertiary and pre-Tertiary basalts and andesites; deeply dissected and mountainous ridges; 0-800 m
Bc32-3c	Fo Bf	R Je G	Stony	258	3 000-4 000 mm; 22-25°C	Solomon Islands: Choiseul, Fauro, Santa Isabel	Lowland forest; shifting cultivation for food crops, coconut estates and groves	Tertiary to Recent basaltic and andesitic volcanics with minor sediments; dissected mountainous ridges and minor alluvial valleys; 0-1 000 m
Bc33-3c	Fo Be	Jc R Tv	Stony	78	2 000-5 000 mm; 22-25°C	Solomon Islands: Ganongga, Rendova, Tetipari, Cizo	Lowland forest; small areas of low fern regrowth, scattered shifting cultivation and cattle under coconuts	Tertiary sediments derived from basic volcanics, dissected ridges and marine terraces; 0-900 m
Bc34-3c	Hh E	G Je Fo	Stony	522	3 000-5 000 mm; 22-25°C	Solomon Islands: Choiseul, Santa Isabel, Malaita	Lowland forest; shifting cultivation for agricultural and subsistence food crops and scattered coconut groves	Calcareous Tertiary sedimentary rocks; dissected hills, ridges, karst, floodplains and fresh water swamps; 0-700 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Bc35-3c	Fo E	R		230	2 000-7 500 mm; 25°C	Solomon Islands: Guadalcanal, Florida, Santa Cruz	Lowland forest and grassland; extensive areas under shifting cultivation and small coconut groves	Tertiary sediments derived from basic volcanics with small areas of ultrabasic and dioritic rocks, minor limestone deposits; dissected ridges, cuestas and karst; 0-800 m
Bc36-3bc	Fo Je	R		86	3 000-5 000 mm; 23-25°C	Solomon Islands: Guadalcanal, Choiseul	Lowland forest; shifting cultivation for food crops, coconut groves	Late Quaternary to Recent volcanoes; low, lightly dissected to deeply dissected flows and ridges; 0-1 200 m
Bc37-3c	G Fo	R	Stony	179	3 000-5 000 mm; 23-25°C	Solomon Islands: San Cristóbal, Santa Cruz	Lowland forest, with low fern scrub and swamp forest; subsistence cultivation for food crops and small coconut groves near coast	Tertiary and pre-Tertiary basaltic and andesitic volcanics; deeply dissected and mountainous ridges with inland swamps; 0-1 300 m
Bc38-3b	Hc Fo	Je	Stony, lithic	179	3 000-4 000 mm; 23-25°C	Solomon Islands: San Cristóbal, Ugi	Lowland forest and littoral forest; subsistence cultivation for food crops with coconut groves near the coast	Calcareous Tertiary sediments forming dissected hills and ridges, and raised Pleistocene coral platforms
Bc39-3c	Bd Fr	Ao Je	Stony	354	2 500-5 000 mm; 26°C; very weak or no dry season	Fiji; east Viti Levu, Mbengga	Forest; now agriculture in valleys	Andesite and basaltic volcanic rocks; uplands; 0-1 300 m
Bc40-3c	Lc Be	I	Stony[2]	39	2 000-2 500 mm; 26°C; mainly weak dry season, some moderate to north and west	Fiji: Ovalau, Ngau	Forest; some subsistence cropping	Various volcanic rocks; steep mountains, coastal flats, fringing reefs; 0-700 m
Bc41-3c	Lc Hh	Je		73	2 000-3 000 mm; 26°C; moderate dry season in north	Fiji: Kandavu, Ono	Forest, grassland to north; now subsistence cropping	Various volcanic rocks; mountainous, some lowlands and alluvial plains; 0-800 m
Bc42-3c	Ao	Ge	Saline[2]	90	2 000-3 000 mm; 26°C; strong dry season	Fiji: northeast Vanua Levu	Grass and fern land; now some plantation crops, sugarcane and subsistence crops	Acid andesites and rhyolites; mountainous, some alluvial flats; 0-600 m
Bc43-3bc	Lc Bf	Be Fr	Stony	98	2 000-4 000 mm; 26°C; moderate to strong dry season	Fiji: north Vanua Levu	Grass and fern land; now some subsistence cropping	Andesite and basalt agglomerate flow rocks and tuffs; mountainous, with some coastal lowlands; 0-700 m
Bc44-3c	Ao	Je Be	Stony	274	2 000-5 000 mm; 25°C; very weak or no dry season	Fiji: south Vanua Levu	Forest; now subsistence cropping on coast	Andesite and basalt; mountainous; 0-1 000 m
Bc47-3bc		Be Fo		445	1 200-3 000 mm; 23-24°C	New Caledonia	Rain forest and Niaouli savanna; grazing natural pasture, timber production	Schist, gneiss, greywacke, granodiorite, gabbro; deeply dissected; 0-1 000 m
Bd2-2c	I		Lithic	1 533	1 200 mm; 11°C; 5.46, 7.81	New Zealand: South Island	Lowland short tussock grasslands, subalpine grass and shrublands; now some extensive sheep farming	Schist, schist deposits, loess; steep and mountainous lands; 300-2 000 m
Bd3-2a			Stony	555	800 mm; 12°C; 5.46	New Zealand: South Island	Lowland short tussock grassland; now intensive sheep farming	Greywacke alluvium, loess; down and terrace lands; 0-350 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Bd3-2bc				453	800 mm; 11°C; 5,46, 7.21	New Zealand: South Island	Lowland tall, some short tussock grassland; now semiextensive sheep farming	Schist and schist deposits, loess; hill and down lands; 300-1 500 m
Bd3-2c				287	1 300 mm; 9°C; 7.21, 7.81	New Zealand: South Island	Podocarp-mixed hardwood forest, lowland tall tussock grassland; semiextensive to intensive sheep farming, dairying	Tuffaceous greywacke, loess; hill lands; 0-700 m
Bd41-3c		Bc	Stony	68	2 500-5 000 + mm; 23°C; very weak dry season	Fiji: central Viti Levu	Forest; now some agricultural use	Acidic rocks; uplands; 100-1 200 m
Bd43-1ab	Pp Rd	Ao Od		117	1 200 mm; 14°C; 7.11	New Zealand: North Island	Scrub and fern; now extensive sheep farming	Dune sands with pumice, slightly consolidated sandstone; dune and down lands; 0-100 m
Bd44-1ab	Ah Rd			24	1 500 mm; 13°C; 7.11	New Zealand: North Island	Scrub and fern; now dairying and intensive-extensive sheep farming	Dune sand with pumice, volcanic ash, soft sandstone; dune lands, down lands; 0-200 m
Bd45-3c	To			422	1 600 mm; 13°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now sheep and beef farming, dairying, forestry	Mudstone, sandstone, limestone, greywacke, volcanich ash; hill and down lands, some steep and mountainous lands; 0-600 m
Bd46-2c	Tv	Be		874	2 000 mm; 13°C; 7.11, 7.12	New Zealand: North Island	Podocarp-mixed hardwood, beech, and beech-podocarp forest; now forestry, semiextensive sheep farming	Greywacke, volcanic ash, argillite, mudstone, sandstone; steep and mountainous lands; 0-1 800 m
Bd47-2c	Be	To		1 189	1 600 mm; 12°C; 7.11, 7.13, 7.14, 7.21, 7.81	New Zealand: North Island	Podocarp-mixed hardwood forest; now semi-intensive sheep and cattle farming, forestry	Sandstone, some siltstone, mudstone, volcanic ash; steep and mountainous lands; 0-1 000 m
Bd48-2c		U		504	2 000 mm; 12°C; 7.13, 7.21, 7.81	New Zealand: North Island	Podocarp-mixed hardwood, beech, beech-podocarp forest, subalpine grass and scrub lands; now semiextensive sheep farming, much undeveloped.	Greywacke; mountainous land; 0-1 600 m
Bd49-2abc		Je	Stony	257	1 300 mm; 13°C	New Zealand: North Island	Scrub and fern, lowland short tussock grassland, podocarp-mixed hardwood forest; now intensive and semiextensive sheep farming	Loess, pumiceous sandstone, alluvium; down and hill land; 200-600 m
Bd50-2c	Be	Lo		527	1 300 mm; 12°C; 7.14, 7.21	New Zealand: North Island	Podocarp-mixed hardwood forest, beech, beech-podocarp forest, scrub; semi-intensive and semiextensive sheep farming; forestry	Greywacke, mudstone, sandstone; steep and mountainous lands; 0-1 600 m
Bd51-2abc		Pp I Bh		496	1 500 mm; 10°C; 7.81	New Zealand: South Island	Beech and beech-podocarp, podocarp-mixed hardwood forest, lowland tall tussock grassland; now some semi-extensive and intensive sheep farming, dairying	Mudstone, sandstone, tuffaceous greywacke, etc.; down, hill, steep and mountainous lands; 0-1 800 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Bd52-2ab		Be	Stony	313	900 mm; 12°C; 5.46, 7.81, 10.5	New Zealand: South Island	Lowland short tussock grassland; now extensive and semi-extensive sheep farming	Loess over greywacke and schist deposits; down and terrace lands; 300-1 500 m
Bd52-1/2c		Be		2 073	1 300 mm; 12°C; 5.46, 7.81	New Zealand: South Island	Beech and beech-podocarp forests, subalpine grass and shrublands; now some extensive sheep farming	Greywacke and greywacke deposits; steep and mountainous land; 0-3 000 m
Bd53-1/2c	Po	I		2 045	2 000 mm; 12°C; 7.12, 7.13, 7.8	New Zealand: South Island	Beech and beech-podocarp forests, subalpine grass and shrublands; undeveloped, some forestry	Greywacke, granite, gneiss etc.; steep and mountainous land; 0-2 500 m
Bd54-1ab	Pg Gd			547	4.000 mm; 11°C; 7.13	New Zealand: South Island	Podocarp-mixed hardwood forest, some beech; now some forestry, dairying	Greywacke, granite, schist deposits; down and terrace lands, bottom lands; 0-300 m
Bd55-2c		Po		246	1 500 mm; 12°C; 7.12	New Zealand: South Island	Beech and beech-podocarp forest; now some semiextensive sheep farming	Sandstones, argillites, subschist; steep and mountainous lands; 0-1 000 m
Bd56-2c	Lg Be	Ag	Fragipan	106	1 100 mm; 11°C; 5.46	New Zealand: South Island	Podocarp-mixed hardwood forest, lowland short tussock grassland; now semi-intensive sheep farming	Loess, basalt; steep and hill lands; 0-1 000 m
Bd57-2c	Ap Lg	Af Od		726	1 500-2 500 mm; moderately seasonal highland climate; wet to intermediate	Papua New Guinea	Lowland rain forest, lower montane forest, swamp; tree crops and pasture possible on flatter areas	Granodiorite, siltstone, sandstone and greywacke; mountainous; 1 500-2 500 m
Bd58-2c	R Ao	Bf I U Lo		10 471	2 500-> 5 000 mm; nonseasonal-wet with some moderately seasonal climates	Papua New Guinea	Lowland rain forest, lower montane forest; tree and arable crops and grazing possible on flatter land	Igneous and sedimentary rocks; mountainous; 500- 1 500 m
Bd59-3c	Ge Lg	Be I E A		4 094	1 500-4 000 mm; moderately seasonal and nonseasonal-wet climates	Papua New Guinea	Lowland rain forest; grazing	Mudstone, siltstone, greywacke, locally limestone, volcanics; mountainous; 0-600 m
Be1-2abc			Stony/ lithic	566	600 mm; 11°C; 5.46	New Zealand: South Island	Lowland short tussock grassland; now sheep farming	Greywacke and schist deposits, some loess; down and terrace lands, hill and steep lands; 300-600 m
Be1-3b				4	2 000-3 000 mm; 20-25°C	New Hebrides: Nguna, Pele, Emau	Plantations and savanna; extensive plantations and gardens, coconut groves	Quaternary basalts forming volcanic cones and lava slopes; 0-600 m
Be89-2b	I R	Lc Lo Ws		451	Summer dominant-medium; 4.31	Australia: Queensland	Eucalyptus forest; now sparsely grazed	Schists, intermediate and acid volcanic rocks, siltstones, limestones, etc.; undulating to hilly with rock outcrops
Be90-2c	Ao Fr	Fx Lo Lc		2 143	Summer-medium; 5.3, 5.4, 5.7, 5.71, 7.8	Australia: central eastern	Alpine communities, eucalyptus forest; some now cleared for grazing	Fine grained sedimentary rocks etc.; hilly to mountainous with rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Be91-2a	Lo Lc	Ws Kh		51	Summer-medium; 5.76	Australia: central eastern	Woodlands; now irrigated for tobacco	Alluvial deposits: plains, river terraces and levees
Be92-3a	Je G	Af		86	1 700-2 300 mm; 25°C	Solomon Islands: Guadalcanal	Lowland forest, fire disclimax grassland and swamp forest; arable cultivation, wet and dry rice, oil palms, coconut, cattle, shifting cultivation	Recent fluviodeltaic sediments; floodplains and low terraces; 0-40 m
Be93-3c	Hh	Je Gh	Stony	122	1 700-2 500 mm; 25°C; moderate to strong dry season	Fiji: north Viti Levu	Savanna, some forest; now agriculture in coastal areas	Andesite and basalt agglomerates and flows; steep uplands; 0-500 m
Be94-3ac	Vp Je	Re Bv		318	800-3 000 mm; 23°C	New Caledonia	Savanna; grazing of some natural pasture	Various basic rocks, basic and ultrabasic alluvium, limestone; deeply dissected, but with extensive flat areas; 0-300 m
Be95-3c	Ah		Stony	68	1 500 mm; 15°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest; now forest and scrub	Dolerite, andesitic basalt, andesite; hill and steep lands; 0-800 m
Be96-3c	Bd		Stony	271	1 600 mm; 14°C; 7.11	New Zealand: North Island	Podocarp-mixed hardwood forest, with kauri; now semiextensive sheep farming, forestry	Andesite, rhyolite, dacite; hill, steep and mountainous land; 0-800 m
Be97-2bc	Hh Lo		Fragipan	129	800 mm; 12°C; 5.46	New Zealand: South Island	Lowland short tussock grasslands; intensive and semiextensive sheep farming	Greywacke loess; hill and steep lands; 0-600 m
Be98-2bc	Lg Lo		Fragipan	243	800 mm; 12°C; 5.46	New Zealand: South Island	Lowland short tussock grassland; now intensive sheep farming and cash cropping, semiextensive sheep farming	Greywacke loess; down and terrace lands, hill lands; 0-300 m
Be99-3b		I Th	Stony	29.9	2 500-3 500 mm; 26°C; weak or moderate dry season	Western Samoa: Savai'i	Lowland forest; now shifting cultivation for subsistence crops, some cocoa	Basalt; undulating to rolling coastal plains; 0-600 m
Be100-3b	To	Bf Bh	Stony	60.9	2 500-4 000 mm; 26°C; moderate to very weak dry season	Western Samoa: Upolu	Lowland and foothill forest; now shifting cultivation, plantation crops, cattle grazing	Basalt; coastal plains and foothills; 0-400 m
Be101-c	Tv			5	3 000 mm; 25°C	New Hebrides; Shepherd islands (Tongoa, Tongariki)	Dense rain forest; coconut plantations, gardens	Basaltic ash and dacitic pumice showing some recent volcanic activity; coasts are steep with high cliffs; 0-500 m
Be102-c	E			4	3 000 mm; 25°C	New Hebrides: Emae	Dense rain forest; coconut plantations, shifting cultivation	Basaltic ash and calcareous alluvium; coast fringed with coral; 0-600 m
Be103-2bc	Re Fa	Th		16	3 000-4 000 mm; 26°C	New Hebrides: Maewo	Rain forest; some subsistence cropping, shifting cultivation, coconut groves, irrigated taro	Volcanic rocks formed from high volcanic island with much erosion; 0-900 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Be104-3bc	Fx Bf	Fh E		4	3 000-4 000 mm; 26°C	New Hebrides: Banks islands (Ureparapara. Saddle. Mota)	Rain forest: some subsistence cropping. coconut groves. shifting cultivation	Volcanic and limestone rocks: high islands with old volcanoes hilly to deeply dissected: 0-1 000 m
Be105-3ab	Re	Je Bv		67	3 000 mm: 26°C	New Hebrides: Espiritu Santo	Rain forest: some subsistence cropping. coconut groves. shifting cultivation	Volcanics and alluvium. erosional features: hills. terraces and plains: 0-500 m
Be106-3c	Hh	Fo Je Gh	Stony	252	1 700-3 000 mm: 25°C: moderate to strong dry season	Fiji: west Viti Levu	Grass and fern land. forest: now agriculture in valleys and on coast	Volcanic and sedimentary rocks of variable composition: steep uplands: 0-1 200 m
Be107-3c	Bc	Fr Bd	Stony	49	2 000-2 800 mm: 25°C: moderate dry season	Fiji: west Viti Levu	Grass and fern land. forest: little used for agriculture	Various volcanic rocks: uplands: 100-1 000 m
Be108-3bc	Bf	Rc	Lithic[a]	24	2 000 mm; 26°C: moderate to strong dry season	Fiji: Yasawa and Mamanutha groups	Grass. scrub and fern: now subsistence crops	Andesitic rocks. some silicified: a line of islands: 0-500 m
Bf19-2c	Nd Ah	Fr Fx Kh		444	Summer dominant-high: 1.132. 1.21. 1.23. 4.44	Australia: Queensland	Rain forest: now small areas cleared for pasture and sugarcane	Phyllites. schists: hilly to mountainous with rock outcrops
Bf20-1/3c	Rc			17	2 000 mm: 26°C: strong dry season	Fiji: Maldo. Qualito	Scrub and fern. grasses: now subsistence crops. coconuts	Highly silicified rocks: steep. with some undulating lowlands: 0-250 m
Bf21-3bc	Fo	Rc Bc	Stony	12	2 000-3 000 mm: 26°C: moderate dry season	Fiji: Lakemba	Grass. scrub and fern: now subsistence cropping. coconuts	Basalt. andesite. fringing limestone: volcanic peaks. uplifted fringing limestone; 0-250 m
Bf22-3ab	Be	Bh I	Stony	76.9	2 500-5 000 mm: 26°C	Western Samoa: Savai'i	Lowland and foothill forest: now some shifting cultivation for subsistence crops	Basalt: coastal plains and foothills; 0-600 m
Bf23-3b		Be Lc	Stony		3 000 mm: 26°C; very weak or no dry season	Eastern Samoa: Manua group	Forest: now some subsistence cropping	Basalt; volcanic cone: 0-600 m
Bf23-3bc		Be Lc	Stony	21	> 3 000 mm: 26°C: very weak or no dry season	Eastern Samoa: Tutuila	Lowland and foothill forest: now some shifting cultivation for subsistence crops	Basalt: steep hills: 0-600 m
Bf24-3bc	Bh	Fo	Stony	53.7	3 500-5 000 mm: 26°C: very weak or no dry season	Western Samoa: Upolu	Lowland to upland forest: now some shifting cultivation for subsistence crops	Basalt; lowlands. foothills and uplands; 0-600 m
Bf25-bc	Bv Fa			1	2 000 mm: 23-24°C	New Hebrides: Tana. Futuna	Secondary forest: some gardens. coconut groves	Limestone and volcanics: volcanic truncated cone with flat summit of limestone. steep coast: 0-600 m
Bf26-3bc	Fh	Bk Bv E		44	3 000-4 000 mm; 26°C	New Hebrides: Maewo. Pentecost	Rain forest: small area used for cropping. shifting cultivation	Volcanic and limestone material: high volcanic island. limestone plateau; 0-300 m
Bf27-3b	Fh	E		10	4 000 mm: 26°C	New Hebrides: Torres islands	Rain forest: small areas used by the population of 200 for gardens and coconuts	Coral limestone in terrace formation on small high islands: 0-350 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Bf28-3ab	Fh	E Je Fx Fr		80	2 000-3 000 mm: 20-25°C: well distributed	New Hebrides: Efate	Rain forest. secondary forest; extensive plantations and gardens with some cropping. coconuts. cocoa. extensive cattle raising	Raised limestone terraces: volcanic hills and plateaus: 0-450 m
Bf29-3ab	Fh	E Je		170	3 000-4 000 mm: 26°C	New Hebrides: Espíritu Santo	Rain forest; some plantation crops. cattle raising and subsistence cropping. large coconut plantations	Limestone and sediments: hilly. coastal terraces and alluvial valleys. plateau of raised coral limestone: 0-200 m
Bf30-3bc	Be Bc	Ao	Stony	88	1 500-2 500 mm: 26°C: moderate to strong dry season	Fiji: west Vanua Levu	Grass and fern land. some forest: now subsistence cropping around coast	Basalt flows. andesites: rolling to steep lowlands and uplands: 0-400 m
Bf31-3abc	Bk	Bc Rc	Stony	24	2 000-3 000 mm: 26°C: moderate dry season	Fiji: north Lau group	Grass and scrub. some forest: now subsistence cropping. coconuts	Andesite. basalt. limestone: volcanic peaks. limestone, often uplifted: 0-300 m
Bh19-2c	I R	Be Oe		437	Alpine: uniform-high: 6.5. 6.53. 7.8. 7.82	Australia: southeastern	Alpine communities. grasslands. woodlands. forests. heaths: now some restricted grazing	Granites. gneisses. basalts, dolorite. metamorphosed sediments etc.: mountainous with rock outcrops
Bh20-2a	Je		Stony	295	650 mm: 11°C: 5.46	New Zealand: South Island	Lowland short tussock grassland.swamp land: intensive sheep farming and cash cropping. dairying	Greywacke alluvium: bottom lands: 0-100 m
Bh21-2c	U Bd	I R		4.965	2 000-4 000 mm: moderately seasonal highland and nonseasonal-wet climates	Papua New Guinea	Lower montane forest: crops possible only in some intermontane valleys	Metamorphic, sedimentary and igneous rocks: mountainous: 500-3 000 m
Bk11-3b		I Rc	Stony	24	2 000-3 000 mm: 26°C: moderate dry season	Fiji: southern Lau group	Grass and scrub. forest: now subsistence cropping. coconuts	Coral limestone. andesite. basalt: volcanic peaks with fringing coral. often uplifted: 0-200 m
Bk43-3a	I Be	Rc	Stony. lithic	20	2 000-2 500 mm: 26°C: moderate dry season	Fiji: Vatulele	Forest: now subsistence cropping. bananas, coconuts	Coral limestone; raised coral island: 0-25 m
Bk43-3b	I Be	Rc	Stony. lithic	20	2 000 mm: 26°C: moderate dry season	Fiji: Thikombia	Forest: now subsistence cropping. coconuts	Coral limestone with some basic tuffs: raised coral island: 0-200 m
Bv19-3ab	Be Re	Je Bf		99	2 000-3 000 mm: 26°C seasonally dry	New Hebrides: Espíritu Santo	Open forest and savanna: rare shifting cultivation. coconut groves	Volcanics and limestone: some erosion of the coastal terraces and hilly areas: 0-1 000 m
Bv20-3a	Hh	Je		14	1 000-2 000 mm: 25-26°C: long dry periods	New Hebrides: Efate	Savanna and open forest: little used. some grazing and cropping in wet season. some coconuts	Limestone and tuffs: raised terraces: 0-400 m
E13-2c	Od I	Lc Ah Lg		1 006	3 000-5 000 mm: nonseasonal-wet climate	Papua New Guinea	Lower montane forest: no potential for cropping	Limestone. locally sedimentary rocks: mountainous: 1 500-3 000 m
E18-3c	Lc I	Re		2 998	3 500-> 5 000 mm: nonseasonal-wet climate	Papua New Guinea	Lowland rain forest, some lower montane forest; little potential for cropping	Limestone: mountainous: mostly below 1 000 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
E20-bc	Bv			1	2 000 mm: 23°C	New Hebrides: Tana (Aniwa)	Secondary forest and coconut plantations	Low volcanic island overlain by coral limestone: 0-50 m
Fa8-3ab	E	Re		261	1 600 mm: 23°C	New Caledonia: Loyalty	Rain forest and savanna: cultivated	Pumice on limestone: terraces: 0-100 m
Fa10-3bc	Be Fp	I		562	800-4 000 mm; 23°C	New Caledonia	Maquis. rain forest: timber production	Ultrabasic rocks: hilly to deeply dissected: 0-1 600 m
Fa13-3bc	Th Fh	Bf		55	3 000-> 5 000 mm: 26°C	New Hebrides: Espiritu Santo	Rain forest: little development. some shifting cultivation at 300-500 m	High island of limestone and volcanics; hilly to deeply dissected. limestone plateaus; 300-800 m
Fh11-3abc	Fr	I Hh		46	1 000-5 000 mm: 20-23°C	Hawaii: Kauai	Forest and grassland: now crops, some irrigated. pasture, woodland	Basic igneous rocks; lowlands and uplands: 0-300 m
Fo7-3a	I G	N H	Stony. saline	178	3 000-5 000 mm: 25°C	Solomon Islands: Shortland. Mono. Choiseul, New Georgia. Wona Wona. Santa Cruz	Lowland and swamp forest: shifting cultivation for food crops. coconut estates. logging	Raised Pleistocene coral platforms with small areas of Tertiary limestones and low freshwater and saline coastal swamps: 0-100 m
Fo10-3c	Bc R	G	Stony	103	3 000-7 000 mm: 22-25°C	Solomon Islands: Choiseul. Santa Isabel. Guadalcanal	*Casuarina papuana* woody heath with coastal swamp forest: unused	Ultrabasics: deeply dissected. rounded mountain ridges: 0-800 m
Fo52-3bc	Fh	B R		258	3 000-5 000 mm: 22-25°C	Solomon Islands: Vella Lavella. Kolombangara. Rendova. Vangunu. Nggatokae	Lowland forest merging to lower montane: shifting cultivation for subsistence crops in some places. logging	Basaltic and andesitic volcanics: lightly dissected planezes and debris slopes. deeply dissected and mountainous ridges: 0-1 000 m
Fo95-3b	Fh I	G	Stony	29	3 000-4 000 mm: 25°C	Solomon Islands: New Georgia	Lowland forest and mixed *Casuarina* forest: largely unused. some shifting cultivation	Tertiary basalts: undulating volcanic ridges. many forming a distinctive ripple pattern: 0-200 m
Fo98-3a	I R	O	Stony	23	3 000-4 000 mm: 25°C	Solomon Islands: Rennel. Bellona	Lowland forest: widely used for shifting cultivation. some coconut groves	Tertiary to Quaternary coral limestone with volcanic impurities: uplifted atolls and lagoons; 0-100 m
Fo100-3ab	Ah	Th	Petric	52	1 600 m: 15°C; 7.11	New Zealand: North Island	Scrub and fern: now semi-intensive sheep and dairy farming. scrub	Basalt: down lands: 0-200 m
Fp17-2b	Qf Fr			1 060	Summer dominant-medium: 1.9	Australia: Northern Territory	Woodlands: some now grazed	Material high in sesquioxides. possibly old laterite: undulating to hilly
Fr1-3ab				16	400-1 000 mm: 20-22°C	Hawaii: Molokai	Scrub and grassland: now pineapple and truck crops with some irrigation. pasture	Basic igneous rocks: mainly gently sloping uplands: 30-400 m
Fr19-3c	Fh			95	2 000 mm; 23°C	New Hebrides: Eromanga. Aneityum	Dense rain forest. with some grassland. fire induced: rare shifting cultivation	Basalts - lava and volcanic agglomerates: parts mountainous with ridges and deep valleys. some with fringing reefs: 0-900 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Fr23-3b	Vp Kh	Hh		23	Summer-medium: 4.4	Australia: Queensland	Heaths: now sown to pastures for dairying, sugarcane	Deeply weathered basalt: undulating
Fr24-1/2a	Fx Fp	Ao Ag Lc		894	Summer dominant-high. summer dominant-medium: 1.4. 4.2. 4.3	Australia: eastern. and Northern Territory	Grasslands: now many crops. sugarcane pineapples etc.: dairying	Materials with high silica and sesquioxides - granites, granodiorites. sandstones. acid volcanic rocks. etc.: plains
Fr25-1/2b	Fx Fp	I R P		4 095	Summer dominant-high: summer dominant-medium: 1.1. 1.4. 1.462. 1.483. 1.485. 4.2. 4.24. 5.4. 6.53. 6.834	Australia: eastern. and Northern Territory	Forests, grasslands: now many crops. sugarcane. pineapples etc.: dairying. some forestry	Materials with high silica and sesquioxides - granites. granodiorites. sandstones. acid volcanic rocks. etc.: undulating to hilly. some rock outcrops
Fr26-2c	Fx I	R Lc Lf		994	Winter-high. uniform-high. summer-medium: 1.21. 1.23. 5.4. 6.53. 7.8	Australia: eastern	Forests: now some improved pastures	Materials with high silica and sesquioxides - granites. granodiorites. sandstones. acid volcanic rocks. etc.: mountainous. some rock outcrops
Fr27-2b	I R	Lc Lo		265	Winter dominant-high. winter dominant-medium: 6.1. 6.183	Australia: Western	Forests: now some horticulture and improved pastures	Materials with high silica and sesquioxides - granites. granodiorites. sandstones. acid volcanic rocks. etc.: steep valley sides. rock outcrops
Fr28-3ac	Ah	Bh Th		32	600-2 000 mm: 13-22°C	Hawaii: Oahu	Trees. shrubs and grassland: now pasture. sugarcane. and pineapple with some irrigation. water supply reserves	Basic igneous rocks. old alluvium: dissected uplands and mountains: 0-1 200 m
Fr29-3ab	Ah	Bh		11	400-2 000 mm: 17-22°C	Hawaii: Lanai	Forest. grassland: now pineapple and truck crops. pasture. woodland	Basic igneous rocks: gently sloping to hilly uplands: 200-800 m
Fx33-2a	YI Ao	Qc Lc Lk	Sodic(Lk)[1]	3 021	Summer dominant-medium. summer dominant-high. summer dominant-low: 1.4. 1.42. 1.462. 1.484. 4.2. 4.31	Australia: eastern	Woodlans: now grazed	Materials high in silica including granites. granodiorites. sandstones. acid volcanic rocks. limestones. sandy sediments: plains
Fx34-2b	I R	Fr Ao Ag		861	Summer dominant-high. summer-medium. uniform-medium: 1.1. 1.43. 1.4. 1.485. 4.2. 4.52. 7.8	Australia: eastern. and Northern Territory	Woodlands: now grazed	Materials high in silica including granites. granodiorites. sandstones, acid volcanic rocks. limestones. sandy sediments: hilly. some rock outcrops
Fx35-2c	I R	Be Ao Fr		364	Uniform-medium: 5.4. 6.834, 7.8	Australia: eastern	Forests: undeveloped	Materials high in silica including granites. granodiorites. sandstones. acid volcanic rocks. limestones. sandy sediments: mountainous with rock outcrops
Fx36-3a	Fh	Bv Fr Bf		38	2 000 mm: 23°C	New Hebrides: Eromanga	Mostly dense rainforest. but with some grassland: shifting cultivation. coconut groves	Raised corals. some lava and volcanic agglomerates: mostly lowland terraces around coast; 0-100 m
Fx37-3bc	Fr	Be Bd		36	3 000-4 000 mm: 26°C	New Hebrides: Espiritu Santo	Rain forest: little development. some shifting cultivation	Volcanics and sediments: hilly to deeply dissected: 0-1 000 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Gd27-3a	Bd Je	Od	Saline	81	3 000 mm; 26°C; very weak dry season	Fiji: southeast Viti Levu	Forest; now mainly agricultural	Alluvium; plains; 0-100 m
Gh17-3a	Od Po	Ph		66	Uniform-medium; 5.42, 7.1	Australia: Victoria	Forests; now improved pastures and specialty crops after drainage	Clayey alluvium; swampy plains
Gh18-3a	Fx			123	Summer dominant-medium; 1.916	Australia: Northern Territory	Woodlands,native pasture; now grazed in dry season	Clayey alluvium; swampy plains with marginal slopes (Fx)
Gh19-2/3a	Od	Ao		151	1 100 mm; 14°C; 7.51	New Zealand: North Island	Swamp, scrub and fern lands, podocarp-mixed hardwood forest; now dairying, intensive sheep farming	Pumiceous alluvium, estuarine mud; bottom lands; 0-200 m
Hg5-3a	Ag J	Lg Od Ap		129	1 500-2 500 mm; moderately seasonal highland climate	Papua New Guinea	Grassland; limited by poor drainage to pastures; when drained suitable for tree crops such as tea and coffee	Recent and subrecent alluvium; flat to gently indulating in highlands; 1 500-2 000 m
Hh1-3a				66	Winter-low; 6.1, 6.23	Australia: South	Shrublands; now sown to pastures	Alluvium; plains
Hh12-3a	Vc Xk			66	Arid-summer; 3.2	Australia: Queensland	Grasslands, native pastures, now sparse grazing	Calcareous rocks;plains, some rock outcrops
Hh13-3b	E Ne	V		282	Summer dominant-medium, summer dominant-low; 1.5, 1.916	Australia: Northern Territory	Woodlands, native pastures; now grazed	Basic igneous rocks; hilly with mesas and buttes
Hh14-3a	Vc Lk	So Ws Ne	Sodic (Lk), petrocalcic (So)[1]	86	Summer dominant-low, summer-low; 4.2211	Australia: Queensland	Woodlands, native pastures; now grazed, some improved pastures in areas of higher rainfall	Calcareous clayey sediments, basalts, diorite, alluvium; gently undulating plains
Hh15-3b	Ne V	L Ws So		295	Arid-summer dominant, arid-summer; 3.2, 4.2	Australia: Queensland	Shrublands, grasslands, native pastures; now grazed	Calcareous clayey sediments, basalts, diorite, alluvium; strongly undulating to low hilly land
Hh16-3b	Kh Hl	V		23	Summer-medium; 4.4	Australia: Queensland	Heaths; now improved pastures	Basalts; undulating and hummocky plains
Hh17-3a	Je	Hl		312	1 000-2 000 mm; moderately to markedly seasonal	Papua New Guinea	Grassland; very suitable for cropping and grazing	Alluvium; gently undulating fans; 100-1 000 m
Hh18-2/3ab	Fr	Tm		65	250-800 mm; 20-23°C	Hawaii: Maui	Shrubs, grassland, some trees; now sugarcane and pineapples, pasture, wildlife reserves	Basic igneous rocks, some coral limestone fans and basins, low and intermediate uplands; 0-700 m
Hh19-3abc	Bv Hc	Fr		32	500-1 000 mm;20-23°C	Hawaii: Kauai	Forest, scrub, grassland; now irrigated sugarcane and other crops, pasture, woodland	Basic igneous rocks; alluvium, sands; coastal plain and uplands; 0-600 m
Hl38-2bc	Be I	R Lc Lo		753	Uniform-medium; 4.1, 5.3, 5.42	Australia: eastern	Forests; now some improved pasture, horticulture and forestry	Shales, some volcanic rocks including basalts; hilly to mountainous
Hl39-2ab	Ne Vp	Vc Lc Lo		172	Summer dominant-medium, summer dominant-low; 4.2	Australia: Queensland	Woodlands; now grazed	Shales, some volcanic rocks including basalts; flat to hilly

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Hl40-2bc	Nd Ah	Lc Lo Ws		286	Summer dominant-high: 4.42. 4.43	Australia: Queensland	Rain forest; now forestry, some sugarcane	Andesites and tuffaceous sediments: hilly to mountainous
Hl41-2b	Lc Lo	Ne Nd I		431	Summer-medium, summer-high: 2.22, 4.2, 4.24, 4.52, 5.45	Australia: Queensland	Woodlands: now grazed, some field crops	Basalts and other basic igneous rocks, some shales and siltstones: hilly, some rock outcrops
Hl42-2ab	Lc N	Kh Hh Ws		318	Winter-medium: 6.2	Australia: Victoria	Woodlands, grasslands, native pastures: now grazed, some improved pastures	Basalts: *plains with volcanic cones and stony rises*
Hl43-2/3b	I Vp	Lc Lo Nd		212	Summer-medium, summer-high: 4.24	Australia: southeastern	Forests, woodlands, native pastures: some now improved, steep areas not used	Basalt: hilly to steep
Hl44-3ab	Ne			9	1 800 mm: 23°C: moderately seasonal	Tonga: Eua	Forest and scrub: subsistence cropping	Andesitic ash on limestone; raised coral island: 0-300 m
I-a				0.1	2 000 mm: 23°C	Walpole Island	Dense scrub: uninhabited, phosphate worked 1920-40	Limestone: raised coral island: 0-100 m
I-1abc			Stony	32	250-1 000 mm: 14-24°C: strongly seasonal	Hawaii: Lanai	Scrub and grassland, forest: now rough pasture, woodland, water supply reserves	Basic igneous rocks: broken stony rocky uplands; 0-1 000 m
I-2b				86	Summer dominant-low: 4.211	Australia: Queensland	Shrublands: undeveloped	Basalt: undulating vesicular lava with organic debris in rock crevices
I-Ah-Pg-3c				65	500-11 000 mm: 13-23°C	Hawaii: Kauai	Scrub and forest, grassland: now water supply reserves, woodland, pasture	Basic igneous rocks and pyroclastics: rough broken mountain uplands: 0-1 600 m
I-Be-2b		Vp Sm Re	Lithic	578	1 000-2 500 mm: moderately to markedly seasonal-wet to dry	Papua New Guinea	Savanna, regrowth and grassland: limited to pastures by shallow soils and dry climate	Sandstone, siltstone, conglomerate, marl, limestone, tuff, some gabbro and dolerite: hilly: 0-1 000 m
I-Fh-Hh-3c			Stony	50	400-6 000 mm: 15-23°C	Hawaii: Oahu	Forest, scrub and fern, grass: now water supply, wildlife and recreation reserves, some pasture	Basic igneous rocks: very steep broken rocky and stony land: 0-900 m
I-Fo-3b		R O	Stony	80	3 000-4 000 mm; 25°C	Solomon Islands: Rennell	Lowland forest: unused	Tertiary to Quaternary coral limestone: raised barrier and uplifted atoll margins: 0-150 m
I-Hh-1c			Stony	17	400-2 200 mm: 20-23°C	Hawaii: Oahu	Trees, shrubs, grass; now pasture, wildlife and recreation reserves	Basic igneous rocks: very steep rocky and stony mountains: 0-800 m
I-Od-U-1c		R		691	2 500-5 000 mm: nonseasonal-wet climate	Papua New Guinea	Montane forest, alpine vegetation; not developed, suitable for national parks	Andesitic, graniodiorite, metamorphics, moraine deposits; mountainous; 3 000-5 000 m
I-Po-Bd-1/2c			Lithic	2 714	5 000 mm: 10°C: 7.21, 7.81, 10.5	New Zealand: South Island	Beech and beech-podocarp forests, subalpine grass and shrublands: undeveloped	Schist, greywacke, granite, gneiss: steep and mountain lands: 0-400 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
I-R-1b			Stony	7 849	Summer dominant-medium. summer dominant-low, arid-summer dominant. arid-summer: 1.542, 1.9. 1.915. 1.916. 3.2	Australia: north and northwest	Woodlands. shrublands: now sparsely grazed in small valleys	Sedentary soils on siliceous rocks - granites. sandstones. quartzites and their colluvium: undulating to hilly. much rock outcrop
I-R-1c			Stony	21 335	Summer dominant-medium. summer dominant-high: 1.4. 1.5. 1.532. 1.542. 1.9. 1.914. 1.916. 3.2. 3.23. 3.24. 3.26	Australia: north and northwest	Woodlands. shrublands: now sparsely grazed in small valleys	Sedentary soils on siliceous rocks - granites. sandstones. quartzites and their colluvium: steeply dissected. much rock outcrop
I-R-2b				8 852	Arid-summer. arid-uniform: 3.1. 3.14. 3.26	Australia: Western	Shrublands: now sparsely grazed	Limestones and dolomites: hilly land. much rock outcrop
I-R-2b					Summer dominant-low. arid-summer dominant, arid-summer. summer-low. arid-uniform. summer-medium: 1.542. 1.9. 3.2. 3.26. 4.2. 4.211. 4.24. 4.31. 1.576	Australia: widespread	Shrublands. grasslands: now some grazing in small valleys	Various rocks and materials such as remnants of the mottled zone of former laterite profiles: undulating to hilly. rock outcrops
I-R-Be-2b		Qa Lc Lo		762	Summer dominant-low: 1.4. 4.2. 4.2211. 4.24	Australia: eastern	Eucalyptus forest: now some sparse grazing	A variety of rocks including metasediments. basic rocks: hilly with rock outcrops
I-R-Be-2c		N H L		1 093	Summer-medium. summer dominant-medium: 4.2. 4.4. 4.44. 5.4. 5.7	Australia: eastern	Eucalyptus forest: not developed	A variety of rocks: mountainous. much rock outcrop
I-R-Qa-2b		Lc Lo	Stony	1 212	Summer dominant-medium: 1.9	Australia: Northern Territory	Shrublands. woodlands: not developed	Greywacke. siltstone etc.: hilly with rock outcrops and some hard laterite
I-R-Qa-2c				1 365	Summer dominant-medium: summer-medium: 4.2	Australia: Queensland	Woodlands: now some grazing in small valleys	Various rocks: mountainous. much rock outcrop
I-R-Qa-2c		Lc So			Summer dominant-low: 3.26	Australia: Western. and Northern Territory	Woodlands. now grazed. mainly in valleys	Phyllites. schists. gneisses; mountainous
I-R-Xk-2b		Xh Yl Lk		2 412	Summer dominant-low: 3.2	Australia: Queensland	Woodlands: now some grazing	Limestone: undulating. much rock outcrop
I-R-Xk-2b		So L Ws			Arid-winter. arid-uniform: 3.2. 3.42. 6.834	Australia: southeast	Woodlands: now some grazing	Phyllites. schists. gneisses etc.: hilly. with rock outcrops
I-R-Yh-2b		Yl		348	Arid-winter dominant; winter dominant-low: arid-winter; 6.812	Australia: Western	Woodlands. shrublands: now grazed	Granites. phyllites and related rocks: undulating to hilly with rock outcrops
I-Rc-a				2.2	2 000 mm: 28°C: strongly seasonal	Nauru	Forest. scrub: some subsistence cultivation. phosphate mining has stripped two thirds of surface	Limestone. guano: raised coral island: 0-65 m
I-Rc-B-c			Stony	1.3	1 700 mm: 19°C: well distributed rainfall	Lord Howe Island	Forest: some cultivation	Volcanic. some coral limestone; 0-870 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
I-Rd-1b				4 843	Summer dominant-medium; summer dominant-low: 1.9. 1.916. 3.2, 3.26. 4.31	Australia: north, northwest	Shrublands, woodlands; now some sparsely grazed	Sands mainly from sandstones and granites: undulating to hilly, much rock outcrop
I-Rd-1b			Stony	4 164	Summer dominant-low; 1.4, 1.542, 1.9, 1.916, 3.1, 3.2	Australia: Northern Territory	Woodlands; now some sparsely grazed	Sands and ironstone gravels from laterite formations; undulating with mesas and buttes underlain by hard laterite
I-Rd-1c				1 468	Summer dominant-low; 1.916, 3.14, 3.26	Australia: north, northwest	Woodlands; now some sparsely grazed in small valleys	Sands mainly from sandstones and granites; steep to mountainous, much rock outcrop
I-Rd-1c					Winter-medium; 6.21, 6.22	Australia: Western	Shrublands; not developed	Sands from granites and quartzites; steep hills, much rock outcrop
I-Rd-Qa-1a		Ws	Stony	411	Winter-low; 6.822, 6.834	Australia: Western	Shrublands: not developed	Sands and ironstone gravels over hard laterite; gently undulating
I-RD-Qa-1b		Qc Ws Yl		745	Summer dominant-medium, winter-high, uniform-high: 1.4, 1.533, 7.1	Australia: eastern. and Tasmania	Heaths, woodlands; now some sparsely grazed	Sands from sandstones, granites, acid igneous rocks; low hills with common rock outcrops
I-Rd-Qa-1c		Qc		1 577	Summer dominant-low; summer dominant-medium; winter-medium, winter-high, summer-medium; 1.485, 4.2, 4.3, 4.31, 4.32	Australia: eastern	Heaths, forests; now some sparsely grazed in small valleys	Sands from sandstones. granites, acid igneous rocks; steep to mountainous with much rock outcrop
I-Th-1abc			Stony	70	250-3 800 mm; 14-24°C; strongly seasonal in drier areas	Hawaii: Molokai	Forest, scrub and grassland: now pasture, wildlife and water supply reserves	Basic igneous rocks: rough broken uplands; 0-1 500 m
I-Th-Be-1ab			Stony	21.4	2 500-4 000 mm; 26°C; weak cr moderate dry season	Western Samoa: Savai'i	Lowland forest, low scrub; not developed	Basalt; coastal plain and rolling foothills; 0-300 m
I-To-Ah-3bc				25	800-4 000 mm; 13-23°C	Hawaii: Maui	Scrub, grass and trees; now pasture, wildlife and water supply reserves, cropping on lower lands	Basic igneous rocks and pyroclastics; rough mountainous uplands; 0-1 800 m
I-Tv-Od-1abc				562	250-6 500 mm; 8-25°C	Hawaii: Hawaii	Lichen, mosses, fern and scrub, forest; now wildlife and recreation reserves, some pasture	Olivine basalt flows and pyroclastics, peat; volcanic lowlands, uplands and mountains; 0-4 200 m
Jd8-2a	Od Gh Ah			59	1 400 m; 13°C; 7.11	New Zealand: North Island	Swamp lands; now dairying, intensive sheep farming	Alluvium, pumiceous alluvium, peat; bottom lands; 0-100 m
Je82-2a	Od			108	1 000 mm; 13°C; 7.11, 7.12	New Zealand: North Island	Podocarp-mixed hardwood forest; now dairying and intensive sheep farming	Alluvium, including volcanic ash, peat; bottom lands; 0-200 m
Je83-2a	Bd	Oe		163	1 200 mm; 12°C; 7.14, 7.21	New Zealand: North Island	Podocarp-mixed hardwood forest; now dairying, intensive sheep farming, cash cropping	Alluvium from greywacke and loess; bottom lands, down lands: 0-100 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Je84-3a	Oe	Jd Hh		1 369	2 000-3 500 mm; moderately to markedly seasonal with some nonseasonal-wet climates	Papua New Guinea	Savanna, lowland rain forest, regrowth and grassland, swamp; highly suitable for arable and tree crops and pasture	Recent alluvium; scattered coastal flats; 10-200 m
Je85-3a	Oe	Jd Gh		7 128	1 500-5 000 mm; moderately seasonal and nonseasonal-wet climates	Papua New Guinea	Swamp, savanna, lowland rain forest, swamp woodland; paddy rice possible in some areas, sago main subsistence crop	Recent alluvium; widely distributed coastal flats; 2-150 m
Kh1-2b			Lithic	530	Summer-medium, winter-medium; 2.2, 4.2, 6.2, 6.21, 6.23	Australia: southeast	Woodlands; now some improved pastures	Basalt, limestone and other calcareous rocks; undulating to steep
Kh3-2a	J Ao	Ws Wd		649	Summer-medium, uniform-medium; 4.1, 4.24, 5.3, 5.42, 5.7, 5.72, 5.76, 5.77	Australia: southeast	Woodlands; now improved pastures and specialty crops	Alluvium from basalt and other rocks; plains
Kh28-2b		Nd	Lithic	116	Uniform-medium; 5.4, 7.1	Australia: southeast	Woodlands; now improved pastures and specialty crops	Residual and colluvial materials from basic rocks including basalts; undulating to hilly
Kh29-2b		Ne V		212	Summer dominant-low; 3.26	Australia: Western	Woodlands; now sparsely grazed	Basalts, shales, limestone; hilly, rock outcrops
Kh30-2a	Bf Fr	Fx Ao		133	Summer dominant-high; 1.21, 1.23, 4.44	Australia: Queensland	Forests; now sugarcane	Alluvium; plains
Kk15-2a	Xk Lk	Vc Rc		189	Winter-low; 6.1	Australia: South	Shrublands (mallee); now improved pastures, wheat cropping, mixed farming	Highly calcareous terrestrial sediments; plains, with dunes
La33-1/2b	Lc Qa	R I Nd		46	Summer-medium; 2.2, 4.24	Australia: Queensland	Forests; now forestry, some grazing	Colluvium largely from metasediments, granites and andesites; hilly
Lc79-1/2a	Yl			669	Summer dominant-high; 1.4, 4.3	Australia: eastern	Woodlands, forests; now grazed, some horticulture	Sediments from granites, granodiorites, sandstones; volcanic rocks, sands etc.; plains, some rock outcrops
Lc80-1/2b	Lo I	R		1 113	Uniform-medium; 6.5, 6.53, 6.834, 7.8	Australia: eastern	Woodlands, forests; now some improved pastures and horticulture	Sediments from granites, granodiorites, sandstones, volcanic rocks, sands, etc.; undulating to hilly, some rock outcrops
Lc81-1/2b	Ws Wd	So Vp Vc		2 783	Summer dominant-medium, summer dominant-low, uniform-medium; 1.4, 1.42, 4.2, 4.21, 4.2211, 4.43, 5.44, 6.5, 6.531	Australia: eastern, and Tasmania	Woodlands, forests; now some sown pasture and wheat and oat cropping	Gneiss, igneous rocks, metamorphic rocks, dolerite, etc.; undulating to hilly
Lc82-1/2b	Lf Ws	So I R	Stony(Lf)[1]	311	Winter dominant-low; 6.1922, 6.1923, 6.812	Australia: Western	Woodlands; now grazed	Alluvium and colluvium from granulite; undulating to hilly with rock outcrops
Lc83-1/2b	Ws Lo	So Vc Yl		802	Winter dominant-low, winter dominant-medium; winter dominant-high; 6.1, 6.183, 6.1922	Australia: Western	Forest, woodlands; now some improved pasture and specialty cropping	Gneiss and basic igneous rocks; rolling to hilly with rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Lc84-1/2b	Ws So	Yl Vc		1 007	Summer dominant-low: 1.542. 1.914. 1.916. 3.14. 3.26	Australia: Western	Woodlands: now grazed	Granites: undulating to hilly land
Lc85-1/2b	Lo Ws	So Wd Be		4 075	Winter-medium. uniform-medium. uniform-high. summer-medium. summer dominant-medium: 4.1. 4.2. 5.3. 5.4. 5.42. 5.45. 6.1. 6.23. 6.5. 6.51. 6.512. 6.53. 7.8	Australia: eastern	Woodlands. forests: now some improved pasture. cropping and horticulture	Granodiorites. granites. phyllites. greywacke. etc.: undulating to hilly
Lc86-1/2b	Lk Ws	So		3 631	Summer dominant-medium. summer-medium. uniform-medium. winter-medium. uniform-high. winter-low: 4.2. 4.2211. 4.32. 5.76. 6.1. 6.23, 6.53. 6.833	Australia: eastern	Woodlands. forests: now some improved pasture. cropping and horticulture	Gneiss. lithic sandstones. shales. granodiorite: undulating to hilly
Lc87-1/2b	I R	Ws Wd		157	Winter-medium. summer dominant-medium: 6.1	Australia: eastern	Forest: now some sown pastures	Granitic rocks: hilly
Lc88-1/2b	Ws So	I R Fx		89	Summer dominant-low. summer dominant-medium: 4.2211	Australia: Queensland	Woodlands: now grazed	Mixed colluvium: hilly
Lc89-2b	Ne Kh	E		83	Uniform-medium: 6.53	Australia: New South Wales	Woodlands; now arable farming. some sown pastures	Basalts. lithic and feldspathic. etc.: undulating
Lc90-2b	R I	Fx Ao		99	Summer-high: 4.1	Australia: New South Wales	Forests: now grazed. banana growing	Mixed colluvium: hilly
Lc91-1/2b	Ws So	Vp R I		580	Winter-medium: 5.4. 6.2	Australia: southeast	Woodlands: now some sown pasture. forestry	Mixed colluvium and alluvium: undulating to hilly
Lc92-2b	Hl Ne	Vp Ws So		500	Summer-medium: 4.2. 5.4. 5.7	Australia: eastern	Woodlands. grasslands: now grazed	Basalt: hilly and steep dissected plateau
Lc93-1/2b	So	Ws I R	Sodic	646	Winter-dominant-medium; 5.76. 6.1. 6.23. 6.834	Australia: eastern	Woodlands: now some sown pastures	Various rocks. including shales and lithic sandstones: undulating to hilly
Lc94-1/2ab	So	Lk Vc Yl I	Sodic (Lk. Lc)[1]	530	Arid-summer. arid-summer dominant; 3.2. 3.26	Australia: Queensland	Shrublands: now grazed	Mixed alluvium and colluvium: plains. often gravel strewn
Lc95-2a	E	Je		685	2 000- > 5 000 mm: nonseasonal-wet and moderately seasonal climates	Papua New Guinea islands	Lowland rain forest: high capability. especially for tree crops such as coconut	Pleistocene and recent coral sand: flat: 0-60 m
Lc96-3b	Hl	Nh		3.4	1 300 mm: 19°C: well-distributed rainfall	Norfolk Island	Forest: now grassland farming, gardening	Basalt flows and tuff: 0-320 m
Lf98-1/2b	Qa P	Ao Ag Ws	Stony	719	Winter dominant-high: 6.2, 6.21	Australia: Western	Forests: now forestry. sown pastures	Laterite: undulating to hilly dissected laterite plateaus. extensive hard laterite
Lf99-1/2b	Lo Lc	Ws So Fr	Stony	222	Winter dominant-high: 6.2	Australia: Western	Forestry: now forestry. sown pastures	Laterite: hilly dissected laterite plateaus. extensive hard laterite
Lf100-1/2b	Ws P	Re	Stony	623	Winter-medium: 6.2. 6.21. 6.23	Australia: South	Forests: now forestry. sown pastures. some horticulture and viticulture	Laterite: undulating to hilly dissected laterite plateaus

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Lf101-1a	P		Duripan	53	Winter-medium; 7.1	Australia: Victoria	Forests; now sown pastures	Alluvium; plains
Lf102-1b	Rd P	Ws So		233	Winter-high, summer-medium; 4.24, 7.24, 7.8	Australia: eastern, and Tasmania	Forests, heaths; now some sown pastures	Alluvium and colluvium; undulating to hilly
Lf103-1c	P Rd	Ah Ag Nd		364	Uniform-high; 7.24, 7.8	Australia: Tasmania	Forests; undeveloped	Alluvium and colluvium; mountainous
Lg22-2a		Bd		126	1 000 mm; 13°C; 7.14, 7.21	New Zealand: North Island	Scrub and fern, some forest; now dairying, intensive sheep farming, cereal cropping	Loess, alluvium; down lands; 0-300 m
Lg38-2bc	Ag	Hh	Fragipan	233	750 mm; 11°C; 5.46	New Zealand: South Island	Lowland short tussock grassland; now intensive sheep farming, cash cropping, semi-extensive sheep farming	Greywacke loess; down and terrace lands, hill lands; 0-300 m
Lk6-1/2b	So	Vp Vc	Sodic, petrocalcic (So) [1]	233	Uniform-medium, uniform-low; 2.2, 5.42, 6.2	Australia: Victoria	Woodlands; now some sown pasture, wheat and oat cropping	Basaltic colluvium probably mixed; undulating with stony rises
Lk7-1/2a	So	Ws Vp Vc	Sodic, petrocalcic (So) [1]	3 478	Summer-low, summer-medium; 4.2211, 5.7, 5.76	Australia: eastern	Woodlands; now some improved pastures, some wheat, some irrigated horticulture, crops and pastures	Alluvium; plains
Lk7-1/2a	So	Ws Vp Vc	Sodic, petrocalcic (So) [1]		Summer dominant-medium; 4.1, 4.21, 4.31	Australia: Queensland	Woodlands, native pastures; now grazed	Alluvium; plains
Lk7-1/2b	So	Ws Vp Vc	Sodic, petrocalcic (So) [1]	2 571	Summer-low; 4.2	Australia: Queensland	Woodlands, native pastures; now grazed	Alluvium and colluvium; undulating to hilly
Lk7-1/2b	So	Ws Vp Vc	Sodic, petrocalcic (So) [1]		Summer-low, summer-medium; 4.2	Australia: eastern	Woodlands; now some sown pastures, wheat and sorghum	Alluvium and colluvium; undulating to hilly
Lk7-1/2b	So	Ws Vp Vc	Sodic, petrocalcic (So) [1]		Summer-low; 4.2	Australia: eastern	Woodlands, native pastures; now grazed	Alluvium and colluvium from limestones and dolomites; undulating
Lk8-1/2ab	So	Vp Vc Xk	Sodic, petrocalcic (So) [1]	2 392	Winter-low, winter-medium, arid-winter; 3.43, 5.76, 6.1, 6.193; 6.21, 6.822, 6.833, 6.883	Australia: South	Woodlands; now wheat, lucerne, sown pastures, horticulture, viticulture, vegetables	Slates, calcareous shales, calcareous alluvium and colluvium; flat to hilly
Lk9-1/2a	Lc Ws	Vp I R		364	Summer-medium, uniform-medium; 5.76	Australia: New South Wales	Woodlands; now some wheat, sown pastures	Slates, calcareous shales, calcareous alluvium and colluvium; flat to very gently undulating
Lk10-1/2b	Lc Ws	Ne I R		497	Uniform-low, summer-medium; 5.76, 6.834	Australia: New South Wales	Woodlands; now some wheat, sown pastures	Slates, calcareous shales, calcareous alluvium and colluvium; undulating
Lk11-1/2a	So	Ws Xk Yl	Sodic, petrocalcic (So) [1]	5 086	Arid-winter, arid-winter dominant; 1.913, 3.1, 3.14, 3.24, 3.25, 3.26	Australia: Western	Shrublands, native pasture; now grazed	Calcareous alluvium; plains
Lk11-1/2b	So	Ws Xk Yl	Sodic, petrocalcic (So) [1]	914	Winter dominant-low, winter-low; 6.1, 6.8, 6.822	Australia: Western	Woodlands; now wheat growing with associated grazing	Calcareous alluvium and colluvium; undulating

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Lk12-1/2b	So	I R Yh	Sodic, petrocalcic (So)[1]	11 830	Arid-summer, arid-summer dominant, arid-uniform: 3.14, 3.2, 3.26	Australia: Western	Shrublands, native pasture; now grazed	Calcareous alluvium and colluvium: undulating to hilly
Lk13-1/2a	So	Vc Ws Yl	Sodic, petrocalcic (So)[1]	11 462	Winter-low, uniform-low, uniform-medium, arid-summer dominant, arid-summer, summer-low: 4.2, 4.2211, 5.7, 5.76, 6.23, 6.24, 6.8, 6.833, 6.834, 6.85, 6.88	Australia: eastern	Woodlands, shrublands; now wheat with grazing; under irrigation sown pastures, horticulture, viticulture; in wetter areas dryland horticulture, viticulture	Calcareous alluvium; plains
Lk14-2c	So	Ws I R	Sodic, petrocalcic (So)[1]	239	Summer-low: 4.2	Australia: Queensland	Woodlands, native pasture; now grazed	Various rocks, including shales and lithic sandstones: mountainous
Lk15-1/2a	So	Vc Ws	Sodic, petrocalcic (So)[1]	53	Summer-low: 4.2	Australia: eastern	Woodlands; now some sown pastures, wheat and sorghum	Alluvium: plains
Lk16-1/2b	So	Ws Lc Vc	Sodic, petrocalcic (So)[1]	401	Summer-low: 4.2	Australia: eastern	Woodlands, native pastures; now some improved pastures	Alluvium and colluvium: undulating to hilly
Lk17-1/2a	So	Ws Lo Vp	Sodic (Lo,Lk), petrocalcic (So)[1]	550	Summer dominant-medium: 4.2	Australia: Queensland	Woodlands, native pastures; now some sown pastures	Alluvium: plains
Lk18-2a	Lo		Saline	96	400 mm; 11°C; 5.92	New Zealand: South Island	Lowland short tussock grassland; now extensive sheep farming, intensive with irrigation, fruit growing	Schist and greywacke alluvium, some stony, loess in places: intermontane terrace lands: 200-500 m
Lo35-2bc	Be		Fragipan	225	900 mm; 13°C; 7.12	New Zealand: North Island	Scrub and fern; now intensive sheep farming	Sandstone, argillaceous sandstone: down and hill lands: 0-300 m
Lo52-1/2b	R I	Lc Ws		392	Winter-medium, summer dominant-medium, summer-medium: 4.2211, 4.32	Australia: eastern	Forests, native pastures; now some sown pastures, forestry	Variety of sedimentary and acid igneous rocks: undulating to hilly
Lo53-1/2a	Lf R	I	Stony (Lo, Lf)[1]	497	Summer dominant-medium, summer dominant-low: 1.5, 1.916	Australia: Northern Territory	Forests; some now cleared for grazing	Dissected laterized sediments: plains flanked by scarps
Lo54-1/2b	Lc Lf	Fr Ne P		66	Winter dominant-high: 6.2	Australia: Western	Forests; now some sown pasture, forestry	Gneissic and granitic rocks: hilly with rock outcrops
Lo55-1/2b	Lc I	R Ws So		696	Winter-medium, uniform-medium, summer-medium, summer dominant-medium: 5.7, 6.21, 7.14	Australia: eastern	Woodlands, forests; now some sown pasture, forestry	Variety of rocks including mica schist, andesites, granites: undulating to hilly with rock outcrops
Lo56-1/2c	Lc Ao	Nd R I		265	Winter-high, winter-medium: 6.21, 7.14	Australia: southeast	Forests; now some sown pasture, forestry	Variety of rocks: mountainous
Lo57-1/2b	I Re	Rd Lc		182	Winter-low, winter-medium: 6.1	Australia: eastern	Woodlands; now some sown pastures; dryland horticulture and viticulture in South Australia	Variety of rocks, including mica schists, granites: hilly with rock outcrops
Lo58-1/2a	So	Ws Wh	Sodic	60	Summer dominant-high: 1.21, 1.36, 4.44	Australia: Queensland	Woodlands; now some sown pastures	Alluvium: plains

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Lo59-1/2b	So	Rd I Qf	Sodic	245	Summer dominant-medium: 1.5. 4.2. 1.9	Australia: Western	Woodlands, native pastures: now grazed	Shales and sandstones: undulating
Lo60-1/2a	So	Ws Lc	Sodic. petrocalcic (So) [1]	142	Summer dominant-high: 1.36. 4.44	Australia: Queensland	Woodlands: now some sown pastures	Alluvium: plains
Lo61-2/3c	Ao Bd			231	1 000 mm: 13°C: 7.14	New Zealand: North Island	Scrub and fern. forest: now semiextensive to semi-intensive sheep farming	Mudstone. argillite: hill lands: 200-600 m
Lo62-2bc	Ao Lg			103	1 000 mm: 12°C: 7.14	New Zealand: North Island	Scrub and fern: now intensive sheep farming	Loess. sandy mudstone. mudstone. sandstone. calcareous mudstone: down lands: 0-300 m
Lo63-1/2bc	Be	Lk	Lithic (Be) [1]	89	500 mm: 10°C: 5.92	New Zealand: South Island	Lowland short tussock grassland: now extensive sheep farming	Greywacke and schist deposits. some loess: hill. steep and mountain lands: 150-750 m
Nd56-2/3b	Ah Hl	Fr Kh Lc		66	Summer dominant-medium: 1.42. 4.21. 4.44	Australia: northeast	Rain forest: now forestry. improved pastures for dairying. maize. groundnuts. sugarcane	Basalt and similar basic igneous rocks: undulating to hilly
Nd57-2/3bc	Ah Hl	I R Kh		507	Summer dominant-high: 2.2. 4.1. 4.21. 4.24. 4.42. 4.44	Australia: northeast	Rain forest: now forestry. some development for pastures. crops	Basalt and similar basic igneous rocks: steep to mountainous. some rock outcrops
Nd58-2/3b	Ah Fr	Fx Lc Lo		331	Summer-medium: 4.2. 5.3	Australia: eastern	Forests; now forestry. some improved pastures. sugarcane	Granites and other acid igneous rocks: hilly
Nd59-2/3c	Ah Fr	Fx I R		1 424	Summer-medium. uniform-medium: 1.36. 4.2. 4.21. 4.24. 4.44. 5.4. 5.42. 5.45	Australia: eastern	Forest: now forestry	Granites and other acid igneous rocks: mountainous with rock outcrops
Nd60-2/3b	Lc Lo	Hl Fr Fx		1 027	Summer-high. winter-high. winter-medium: 4.1. 5.4. 6.5. 7.1. 7.14. 7.24. 7.8	Australia: southeast Tasmania	Forests: now improved pastures. some specialty crops. forestry	Basalt: hilly
Nd61-2/3c	Be Bh	Ah Fr Fx		2 143	Summer-high. uniform-high. winter-high. alpine: 4.24. 5.45. 6.53. 7.1. 7.82	Australia: southeast Tasmania	Forests: now forestry. some improved pastures. some specialty crops	Basalts: mountainous
Nd62-3ac	Fo R	I	Stony. saline	46	3 000-4 000 mm: 25°C	Solomon Islands: Russell islands	Lowland forest: extensive clearing and replanting of coconuts, some interplanted cocoa	Raised Pleistocene coral platforms surrounding older dissected ridges of Tertiary basaltic and andesitic volcanics: 0-500 m
Ne61-2/3ab	Vc Vp	Xk Xh		1 027	Summer dominant-medium. summer dominant-low. arid-summer dominant: 1.5. 1.9. 1.914. 3.2	Australia: northern	Woodlands. native pastures: now grazed	Basalts and similar basic igneous rocks: plains and undulating land
Ne62-2/3b	Vc Vp	I R Xk		1 014	Summer dominant-medium. summer dominant-low: 1.5. 1.541. 1.9. 1.914. 1.916	Australia: northern	Woodlands. native pastures: now grazed	Basalts and similar basic igneous rocks: hilly
Ne63-2/3ab	Vc Vp	Lc H		1 610	Summer dominant-medium. summer dominant-low; uniform-medium, summer-medium: winter-medium: 4.2. 4.2211. 4.32. 5.72. 5.76	Australia: eastern	Woodlands: now some improved pastures. wheat cropping	Basalts and similar basic igneous rocks: flat to strongly undulating

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ne64-2/3b	Lc H	Vp Vc		912	Uniform-medium: summer-medium. summer dominant-medium: 1.9. 5.4. 5.45. 5.71	Australia: eastern	Woodlands: now some improved pastures. wheat cropping	Basalts and similar basic igneous rocks: hilly
Od1-a				41	1 300 mm: 9°C: 7.81	New Zealand: South Island	Swamp lands: undeveloped	Peat: bottom lands: 0-20 m
Od16-2a	P Wd	Ws		133	Uniform-medium: 5.4	Australia: southeast	Swamps of reeds and rushes: now improved pastures. vegetables. specialty crops	Plant remains: plains
Od17-a	Bd Ah			75	85 mm: 11°C	New Zealand: Chatham islands. Pitt Island	Broadleaf-Drocophyllum forest: now extensive sheep and cattle farming	Basaltic rocks. tuffs: sands. schist: low. mainly volcanic. with extensive peats: 0-300 m
Oe9-a	Ge		Saline	685	1 500-3 000 mm: nonseasonal-wet and moderately to markedly seasonal climates	Papua New Guinea	Mangroves: salinity. flooding and poor drainage prevent development	Peat and alluvium; scattered flat coastal areas: 0-20 m
Ph4-1ab	Po Rd	Ws		1 179	Winter dominant-high. winter dominant-medium: 5.42. 6.1. 6.183. 6.1922. 6.2. 6.23	Australia: Western	Forests, heaths; now some improved pastures and pine plantations	Older coastal plains and dunes
Ph6-1ab	Po Pg	Rd W Rc		679	Winter-medium. winter-high. summer-high: 4.1. 4.4. 5.42. 7.1. 7.14	Australia: southern. eastern. and Tasmania	Forests. heaths: now some improved pastures. pine plantations. vegetable growing	Older coastal plains and dunes
Ph7-1b	Pg Po	Rd Re W		845	Uniform-high. winter-medium: 4.1. 5.42. 6.2. 6.21. 7.13. 7.14	Australia: southern. eastern. and Tasmania	Forests, heaths: now some improved pastures. pine plantations	Older coastal dunes and sandhills: undulating to hilly
Ph10-1bc	Rd Po			457	Summer-medium. winter-high: 5.4. 7.14	Australia: southern. eastern	Woodlands. forests. heaths: undeveloped. some grazing in minor valleys	Sands from granitic rocks: hilly. some steep slopes. much rock outcrop
Ph11-1c	Pg Rd	I Od A		739	Uniform-high; 7.13. 7.23. 7.8	Australia: Tasmania	Forests: undeveloped	Sands from a siliceous rock basement: mountainous
Po11-1bc	Bd			52	1 300 mm: 9°C: 7.21	New Zealand: South Island	Podocarp-mixed hardwood forest: now some semiextensive sheep farming	Tuffaceous greywacke: hill lands: 0-700 m
Po16-1b	Ph Pg	Rc Rd Ws		709	Winter dominant-high. winter-medium. winter-low. winter dominant-low: 6.1922. 6.1923. 6.21. 6.812	Australia: Western	Forests. heaths: now some areas of sown pasture. largely undeveloped	Older coastal dunes and sand sheets: undulating dunes. hard laterite on residual ridges
Po17-1a	Ws		Stony	235	Winter-low: 6.1922, 6.22	Australia: Western	Heaths: now some improved legume-based pastures	Sands with ironstone gravel overlying hard laterite: flat to undulating
Po18-1b	I R			33	Winter-medium: 6.1922	Australia: Western	Heaths. shrublands: largely undeveloped	Sands derived from a basement of granitic rocks: hilly. much rock outcrop
Po19-1b	Re So			1 328	Winter-low. winter-medium: 6.1. 6.21. 6.23. 6.833. 6.834	Australia: South	Forests. heaths: now some cropping. improved pastures and pine plantations. but largely undeveloped	Older coastal dunes and sand sheets: undulating dunes and sandhills. exposed sheet limestone

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Po21-1b	Ph Ws			56	Uniform-high: 5.4	Australia: Victoria	Forests: now some improved pastures and *pine plantations. but* largely undeveloped	Older coastal dunes: low hills
Po22-1b	Ph Od	G		113	Uniform-high. summer-medium: 4.1. 5.3	Australia: New South Wales	Forests: largely undeveloped	Older coastal dunes: dunes and swales
Po23-1bc	Ph Rd	Qa		265	Summer-medium: 4.1	Australia: Queensland	Eucalyptus forest: now forestry	Older coastal dune formations: hilly. some steep slopes
Po24-1a	Ph A	Ws Qa		994	Summer dominant-medium. summer dominant-high: 1.1. 1.244. 1.4, 1.462. 1.484. 4.2211	Australia: Queensland	Woodlands. heaths: now some sparse grazing	Sands from siliceous rocks - granites. quartz porphyry. quartzose sandstone: flat to gently undulating
Po25-1bc	Qa A	F Ws L		656	Summer dominant-medium. summer dominant-low: 1.132. 1.485. 4.2. 4.2211	Australia: Queensland	Woodlands: largely undeveloped. some grazing in small valleys	Sands from siliceous rocks - granites. quartz porphyry. quartzose sandstone: hilly to mountainous
Po26-1ab	Ao Rd	Gd Od		147	1 200 mm: 14°C: 7.11	New Zealand: North Island	Scrub and fern: now semiintensive sheep farming	Weathered sands: dune lands. down lands: 0-200 m
Pp2-2bc	U Od	Bd I		179	2 000 mm: 9°C: 7.31	New Zealand: Stewart Island	Podocarp-mixed hardwood forest. subalpine grass and scrublands: undeveloped	Granite. diorite: steep and mountainous lands: 0-100 m
Qa9-2b				1 928	Summer dominant-medium. summer-medium: 1.4. 1.42. 1.5. 1.533. 4.21. 4.31. 4.32. 4.4. 4.52	Australia: Queensland	Woodlands. forests. native pastures: now sparsely grazed	Shales. slates. cherts. tuff. trachyte. etc.: hilly with some rock outcrop
Qa11-1a	Po Wd	Ws	Lithic. stony	222	Winter dominant-high; 6.2	Australia: Western	Jarrah (*Eucalyptus marginata*) forests	Sands overlying hard laterite on granitic basement: flat to undulating. much boulder laterite and ironstone gravel
Qa12-1a	F A	Ws	Lithic	172	Summer dominant-low: 1.5. 2.2. 4.2211. 4.24	Australia: Queensland	Woodlands: undeveloped	Sands overlying hard laterite: plains
Qa13-1b	Qf I		Lithic	1 636	Summer dominant-medium, summer dominant-low: 1.916	Australia: Northern Territory	Woodlands: now some sparsely grazed	Sands overlying hard laterite: undulating to low ridges and hills
Qa14-1b	I Po	A Ws	Lithic	974	Summer dominant-low. summer dominant-medium. summer-medium: 4.2. 4.2211. 4.32. 4.24. 4.4	Australia: Queensland	Forests: largely undeveloped	Sands from basement of quartzose sandstone. granite and acid volcanic rocks: undulating to low hills with much rock outcrop
Qa15-1c	I A		Lithic	46	Summer dominant-medium, 1.42	Australia: Queensland	Forests: largely undeveloped	Sands from basement of *granitic rocks: mountainous.* much rock outcrop
Qa16-2c	I R			649	Summer dominant-medium. summer-medium: 1.42. 1.485. 4.2. 4.21	Australia: Queensland	Forests. woodlands: now some grazing in small valleys	Shales. slates. cherts. tuff. trachyte. etc.: mountainous with rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Qc51-1b	Qa Rd	Fx W P	Stony. lithic	1 100	Winter dominant-medium. winter dominant-high: 6.1. 6.183. 6.1922	Australia: Western	Jarrah (*Eucalyptus marginata*) forests: now some pine plantations	Sands and gravels from laterite formations and basement rocks. mainly granites: dissected laterite plateaus. strongly undulating
Qc52-1b	I Rd		Stony. lithic	421	Summer dominant-low: 3.26	Australia: Western	Woodlands; not developed	Sands and gravels from laterite formations and basement rocks: strongly undulating lateritic plateaus
Qc53-1b	Rd I	P W		126	Winter-medium: 6.21. 6.22	Australia: Western	Woodlands. native pastures: some now improved	Sands. mainly from granites. some laterite materials including ironstone gravels: undulating to hilly
Qc54-1ab	Rd Po			378	Winter dominant-medium: 3.24. 6.183. 6.1922. 6.812	Australia: Western	Forests. woodlands: now developed for hardwood and pine forests. some pastures	Older aeolian dunes: plains with dunes
Qc55-1ab	Rd Ws		Stony	2 070	Summer dominant-medium: 1.542. 1.9, 1.914. 3.14	Australia: Western	Woodlands. native pastures: some sparse grazing	Sands from sandstones. some lateritic materials: undulating. some steep residuals
Qc56-1b	Rd I	Qf F A		782	Summer dominant-low: 1.542. 1.9. 4.31	Australia: Northern Territory	Woodlands: now some sparse grazing on small valleys	Sands from sandstones and lateritic formations: dissected plateaus and hills
Qc57-1ab	Qf Qa	F A Ws		596	Summer dominant-medium. summer dominant-low: 1.5. 4.3. 4.31	Australia: Queensland	Woodlands. native pastures: some sparse grazing	Sands from sandstones and granites. some lateritic materials: flat to strongly undulating. some rock outcrop. some hard laterite
Qc58-1b	Rd Qa	Po F A		1 044	Summer dominant-medium. summer dominant-high: 4.2. 4.32	Australia: Queensland	Forests. native pastures: some sparse grazing in small valleys	Sands from granites. acid igneous rocks. quartzites. sandstones. with some laterites: undulating to hilly with rock outcrops
Qf41-1ab	Rd Yl	Xk	Stony. duripan	93 299	Arid-summer dominant, arid-summer. arid-uniform. arid-winter. summer dominant-low: 1.4. 1.5. 1.533. 1.542. 1.914. 1.916. 3.1. 3.14, 3.23. 3.24, 3.25. 3.26. 6.1922. 6.812	Australia: central	Grasslands (spinifex); largely undeveloped	Colluvial sands. mainly from siliceous rocks. hard laterite gravels: plains. undulating with dunes. laterite capped residuals
Qf42-1b	Yh Yl	Rd	Stony	9 567	Arid-summer dominant. arid-summer. arid-uniform: 3.2. 3.23, 3.26	Australia: central	Grasslands (spinifex): largely undeveloped	Colluvial sands. much laterite gravel: undulating uplands. some mesas and buttes with hardened block laterite
Qf43-1b	Yl Lf	Rd Qa	Stony. duripan	5 469	Arid-winter. winter-low. winter dominant-low: 6.1. 6.1922. 6.8. 6.812. 6.822	Australia: Western	Shrublands. woodlands. native pastures: now grazed. cereal cropping on moister margins	Residual and colluvial sands from hard siliceous rocks: undulating and hilly uplands
Qf44-1b	I Yl	Ws	Stony	619	Winter dominant-low. summer dominant-low: 1.9. 1.914. 3.26	Australia: Western	Woodlands. native pastures; some grazed	Residual and colluvial sands from hard siliceous rocks; undulating uplands. some hardened block laterite

See notes at end of table.

TABLE 10 — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Qf45-1a	Yl			3 220	Summer dominant-medium; 1.9, 1.916	Australia: Northern Territory	Woodlands, native pastures; some grazed	Residual and colluvial sands from hard siliceous rocks; plains with low ridges and hills
Qf46-1a	Qc Qa	Yl A F		1 600	Summer dominant-low; 4.3	Australia: Queensland	Woodlands, native pastures; some grazed	Colluvial sands from hard siliceous rocks; plains
Qf47-1b	Qc Qa			66	Summer dominant-medium, summer dominant-low; 4.2211	Australia: Queensland	Woodlands, native pastures; some grazed	Colluvial and residual sands from hard siliceous rocks; undulating land
R2-2/3c	Bc Fo	Je Hh	Stony	408	3 000-7 500 mm; 17-25°C	Solomon Islands: Kolombangara, Santa Isabel, Malaita, Guadalcanal	Lowland forest grading to lower montane forest; shifting cultivation for food crops on some islands, mostly unused	Tertiary and Quaternary basaltic and andesitic volcanics; deep to very deeply dissected hills and mountains; 0-2000 m
R3-3bc	Bd Fa Th			212	3 000 mm; 26°C	New Hebrides: Espíritu Santo	Rain forest; very little development	Volcanic rocks, severe erosion; hilly to mountainous; 0-2 000 m
Rc1-1a			Stony, lithic	0.3	2 500 mm; 26°C; variable rainfall	Eastern Samoa: Swains Island	Low forest, scrub; now subsistence cultivation, coconuts	Coral; atoll; 0-6 m
Rc-1a				0.1	2 000 mm; 23°C	Chesterfield Islands	Forest and scrub; uninhabited, was mined for phosphate	Limestone; coral islets and reefs; 0-4 m
Rc39-1b	Rd Re	Po	Petrocalcic [3]	2 220	Winter dominant-low, arid-winter dominant, winter dominant-medium, winter-medium, winter-low: 6.1, 6.2, 6.21, 6.232, 6.25, 6.833, 7.13	Australia: southern, coastal	Forests, woodlands, grasslands, heaths, native pastures; some grazed, some barley cropping	Aeolian calcareous sands; coastal dunes and sand sheets
Rc41-1a	Rd Yl	Xk		199	Arid-summer; 3.26	Australia: Northern Territory	Shrublands, woodlands; now sparsely grazed	Highly calcareous alluvial sediments; plains
Rc42-1a	I	G O	Stony, saline	14	3 000-4 000 mm; 25°C	Solomon Islands: Santa Cruz, Ndai, Stewart	Beech forests; coconut groves, settlements, subsistence crops	Recent coral reefs and atolls slightly raised, consisting mostly of coral beach debris and minor swamps; 0-5 m
Rc43-1ab	Be	Hl	Stony [2]	1.8	2 500 mm; 26°C; moderately seasonal	Tonga: Niuatoputapu	Forest; subsistence cropping, coconuts	Limestone, andesitic flows and ash on raised volcanic islands with fringing reefs; 0-600 m
Rd1-1b				56 614	Arid-summer, arid-uniform, arid-summer dominant, summer dominant-low, arid-winter; 1.542, 3.1, 3.2, 3.23, 3.24, 3.25, 3.26	Australia: central	Grasslands; now some sparsely grazed on desert fringes, most undeveloped	Aeolian siliceous sands; dunes and swales of sand desert
Rd32-1b	Re Qc	Rc		563	Winter dominant-high, winter-low, winter dominant-medium; 6.183, 6.1922, 6.1923, 6.881	Australia: southwest	Forests, woodlands, shrublands, heaths; now some pine plantations, some vegetables and viticulture, much undeveloped	Aeolian siliceous sands; coastal dunes and sand sheets
Rd33-1b	Rc Re	Po		619	Summer dominant-high, winter-medium, uniform-medium; 1.1, 1.132, 1.4, 1.483, 1.485, 3.26, 5.4, 6.8	Australia: eastern	Forests, woodlands, heaths; now some pine plantations, some sparsely grazed, much undeveloped	Aeolian siliceous sands; coastal dunes and sand sheets

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Rd34-1a	Qc Po	Qf		341	Summer dominant-medium: 1.5	Australia: northwest	Woodlands: now some sparsely grazed	Colluvial-alluvial siliceous sands: sandy plain with small bouldery sandstone hills
Rd35-1bc	I Po		Lithic	4 002	Arid-summer. arid-winter. winter dominant-low. arid-summer dominant. summer dominant-low. summer dominant-medium: 1.4. 1.533. 1.9. 3.1. 3.2. 4.2. 4.4. 6.812	Australia: Western. Northern Territory. Queensland	Woodlands: now some grazed in small valleys. largely undeveloped	Siliceous colluvium-alluvium. largely from sandstones: hills and ridges
Rd36-1a	Re	Yl Q		199	Arid-summer dominant. arid-summer: 3.2	Australia: Northern Territory	Grasslands. woodlands: now some sparsely grazed. largely undeveloped	Siliceous sediments: plains
Rd37-1a	Re	Ws		40	Winter dominant-low: 6.1922	Australia: Western	Woodlands: now some cropping and improved legume-based pastures	Alluvium: plains
Rd38-1c	Re Bc	Nd Be		108	1 500-8000 mm: 23°C	New Caledonia	Niaouli savanna and forest: not used	Schist and schist-gneiss: deeply dissected: 0-1 600 m
Re1-1a				812	Winter-low. winter-medium: 6.1923. 7.1	Australia: South. and Flinders Island	Woodlands. forests. native pastures: some improved. some cultivated for barley	Sandy sediments overlying and/or derived from hard sheet limestone: plains. some coastal dunes
Re1-1c				51	3 000 mm: 25°C	New Hebrides: Ambrim	Rain forest and bare lands: not cultivated	Basaltic ash from truncated cone of a high volcanic island: crater walls up to 600 m above sea level. much erosion takes place: 0-900 m
Re67-1b	I Lo	Lc Lf Ws		368	Winter-medium. winter-low: 6.1. 6.2. 6.21. 6.23. 6.512	Australia: South. and Victoria	Forests. woodlands. native pastures: some improved	Schists and related rocks: hilly with rock outcrops
Re70-1b		Oe		583	Winter-low. winter-medium: 6.1. 6.2. 6.25. 7.14	Australia: South	Woodlands. native pastures: grazed	Sandy sediments overlying and/or derived from hard sheet limestone: undulating to hilly. with rock outcrops
Re71-1ab	Rc		Lithic	222	Arid-uniform. arid-winter: 3.14	Australia: Western	Woodlands. native pastures: some sparsely grazed	Aeolian sands: gently undulating with dunes
Re72-1b	Rc Lk		Lithic. stony.[2] sodic (Lk)[1]	795	Arid-summer. arid-summer dominant. arid-uniform: 3.14. 3.26	Australia: Western	Woodlands, native pastures: some sparsely grazed	Sands from granites. gneiss sandstone often interbedded with dolomite: hilly
Re73-1b	Rc	Xk Ws So		1 491	Winter-low. arid-winter: 3.2. 3.24. 6.8. 6.822: 6.834	Australia: southern	Woodlands. native pastures: some sparsely grazed	Aeolian. often calcareous sands: dunes. swales. sand hills
Re74-1bc	Tv			252	1 700 mm: 12°C: 7.11, 7.51. 7.81	New Zealand: North Island	Lowland tall tussock grassland: now some exotic forest. dairying. intensive sheep farming	Basaltic and andesitic volcanic ash: hill. steep and mountainous lands: 300-1 600 m
Re74-1c	Tv			3	3 000 mm: 25°C	New Hebrides: Ambrim, Lopevi	Rain forest and bare lands: some shifting cultivation on lowlands	Basaltic ash from active volcano: 0-1 400 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Re75-1ab	Ge Be	Oe	Shifting sand	109	1 000 mm: 12°C: 7.14	New Zealand: North Island	Scrub. fern. dune lands. podocarp-mixed hardwood forest: now dairying. intensive sheep farming. exotic forestry	Wind-blown sand: dune lands: 0-100 m
Re76-c	Bf	Be Fh		34	3 000-4 000 mm: 22-25°C: seasonal dry periods on west coast	New Hebrides: Epi	Rain forest inland: extensive coconut plantations and gardens on coastal terraces	Pliocene volcanics: deeply dissected hills. less steep at western end; 0-600 m
Re77-2bc	Be Tm	Tm Je Bf Fh		149	3 000 mm: 26°C	New Hebrides: Malekula	Rain forest. with some grass: considerable cultivation on east coast for coconuts and cocoa. shifting cultivation inland.. cattle raising	High volcanic island consisting of volcanic rocks and ash: much erosion causing rolling to deeply dissected landforms: 0-900 m
Re78-2bc	Be Bv	Bk Bf Fh		97	2 000-3 000 mm: 26°C	New Hebrides: Malekula	Rain forest. coral terraces covered with grass in northwest: considerable cultivation on east coast for coconuts and cocoa. shifting cultivation inland. cattle raising	High volcanic island consisting of volcanic rocks and ash. covered by recent coral limestone: much erosion. low ranges in the north west with rounded profiles and thick alluvium in valleys; 0-900 m
Re79-3bc	Fx Fr	Fa		21	3 000-5 000 mm; 20-25°C: no dry season	New Hebrides: Efate	Rain forest: not cultivated	Volcanic tuffs and rocks: hilly landforms with deeply dissected plateaus: 200-650 m
So7-1/2a	Vc Vp	Ws Lk	Petrocalcic. sodic (Lk)[1]	331	Summer-low: 4.2. 4.21. 4.2211. 4.43, 5.76	Australia: eastern	Woodlands. native pastures: now some sown pastures	Alluvium: plains
So14-1/2ab	Vc		Saline	23 268	Arid-uniform. arid-summer. arid-winter. uniform-low: 3.2. 3.23. 3.24. 3.25. 3.26. 3.43. 6.8	Australia: central	Shrublands. native pastures: now some grazed	Colluvium and alluvium from rocks including medium to fine grained sedimentary and metamorphics: flat to hilly dissected plateaus and plains
So15-2b	Ws Lk	Vp Vc	Petrocalcic. sodic (Lk)[1]	384	Summer-low; 4.2	Australia: Queensland	Woodlands. native pastures: now some sown pastures	Alluvium: undulating to hilly
So20-2b	Vp Vc	Lk Lc Kh	Petrocalcic	331	Winter-medium. uniform-medium: 4.2. 4.21. 6.2. 6.23	Australia: southeast	Woodlands. native pastures: now some sown pastures	Alluvium: undulating to hilly
So21-1/2b	Ws	Lk	Petrocalcic. sodic (Lk) [1]	2 263	Winter-low. winter dominant-low: 6.1. 6.1922. 6.1923. 6.22. 6.8. 6.822	Australia: Western	Woodlands: now some sown pastures. some wheat	Alluvium: undulating to hilly
So22-1/2a	Ws	Lk Fx Ao	Petrocalcic. sodic (Lk) [1]	205	Summer dominant-medium: 1.5. 1.9	Australia: Northern Territory	Grasslands. native pastures: now some grazed	Alluvium: plains
So23-1/2a	Ws	Lk Lc Vp	Petrocalcic	3 810	Winter-medium. winter-low. uniform medium. summer dominant-medium. summer-medium. summer-low: 1.4. 1.485. 4.2. 4.21. 4.2211. 4.4. 4.42. 4.43. 5.4. 5.76. 6.23. 6.5. 6.51. 6.53	Australia: eastern	Woodlands. native pastures: now some sown pastures	Alluvium: plains

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
So24-1/2b	Ws	Lc Lk Lo	Petrocalcic (So. Ws)	3 690	Winter-medium. uniform-medium. summer-medium. summer-low. summer dominant-medium. summer dominant-low: 4.2. 4.2211. 4.24. 6.1. 6.2. 6.23	Australia: eastern	Woodlands. native pastures: now some sown pastures	Alluvium and colluvium: undulating to hilly
So25-1/2a	Ws	Lk P	Petrocalcic (So. Ws)	36	Winter-medium: 6.2	Australia: South. Victoria	Woodlands: now some sown pastures	Alluvium: plains
So26-1a	Ws	P Rd	Petrocalcic (So. Ws)	921	Winter-medium. uniform-low: 6.1, 6.21. 6.833	Australia: southeast	Woodlands. heaths. forests: now sown pastures	Alluvium: plains
So27-1a	Ws		Petrocalcic (So. Ws)	1 448	Winter-low. winter-medium: 6.1. 6.183. 6.1923. 6.834	Australia: Western	Shrublands. heaths. woodlands: now sown pastures	Alluvium: plains
So27-1b	Ws		Petrocalcic (So. Ws)	1 159	Winter-low. winter-medium: 5.7. 6.232. 6.833	Australia: southeast	Woodlands. heaths. forests: now sown pastures	Alluvium: undulating to hilly
So28-1b	Ws	Rc Re	Petrocalcic (So. Ws)	265	Winter-low: 6.21. 6.23. 6.834	Australia: southeast	Woodlands. heaths. native pastures: some grazed	Alluvium: undulating
Th4-2ab				407	1 500 mm: 13°C: 7.13. 7.14	New Zealand: North Island	Podocarp-mixed hardwood forest. scrub and fern: now dairying. intensive sheep farming	Volcanic ash: down lands. some hills: 0-200 m
Th13-2/3bc	To Bh	Bf	Stony	42.7	3 000-6 000 mm: 26°C: very weak or no dry season	Western Samoa: Savai'i	Lowland. foothill and upland forests: not developed	Basalt: rolling uplands with volcanic cones: 0-1 800 m
Th14-3bc	Fa Be Re	Bf Fh		30	3 000 mm: 26°C	New Hebrides: Pentecost	Rain forest: small population using limited areas in coconuts and shifting cultivation	High volcanic island consisting of volcanic rocks and limestone plateaus: hilly to deeply dissected: 0-1 000 m
Th15-3c		Tv Be Je		54	4 000 mm; 26°C	New Hebrides: Banks islands (Vanua Lava. Santa Maria)	Rain forest: small population using limited areas in coconuts and in shifting cultivation	Recent volcanic rock: islands are high with active volcanoes. hilly to deeply dissected: 0-1 000 m
Th16-2abc	Tm			47	500-1 500 mm: 10-20°C	Hawaii: Maui	Trees. shrubs. and grassland: now truck crops. orchards. pasture. wildlife reserves	Volcanic ash: intermediate and high uplands: 300-2 400 m
Tm15-2c	Th	Bc Bd I		1 735	3 000-5 000 mm: moderately seasonal	Papua New Guinea. Bougainville. New Britain	Lowland rain forest. regrowth and grassland: gently sloping areas highly suitable for crops and pasture. cocoa and oil palm are important	Andesitic volcanic ash: mountainous: 0-2 000 m
Tm16-3ab	Hl	Ne Rc		26	1 700-2 000 mm; 23-25°C: moderately seasonal	Tonga: Tongatapu. Ha'apai group	Forest and scrub: subsistence cropping. some coconuts. bananas. vegetables for export	Basaltic volcanic ash on limestone: raised coral island: 0-80 m
Tm16-3ab	Hl	Rc Ne		14	2 200 mm: 27°C: moderately seasonal	Tonga: Vava'u group	Forest; subsistence cropping. some copra and banana production	Volcanic ash beds: raised coral islands: 0-200 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Tm17-ab	Th	Bc Bf Bv		41	2 000 mm; 23°C	New Hebrides: Tana	Rain forest with some grassland on northwest slopes and terraces; coconuts on coast, coconuts, coffee and gardens on plateau	Andesitic ash; limestone coral bordering coast with andesitic plateau in centre; 0-500 m
Tm18-1b	Tv			4	3 000 mm; 25°C	New Hebrides: Ambrim, Paama	Coconut plantations, gardens	Basaltic ash; 0-500 m
Tm19-bc	Re			10	2 000-3 000 mm; 25°C; nonseasonal	New Hebrides: Epi	Rain forest; some coconut plantations and gardens on coast	Pleistocene andesites; moderately to strongly dissected volcanic cones; 0-800 m
Tm20-2bc	Th Re			41	3 000 mm; 26°C	New Hebrides: Oba	Rain forest; large coconut and cocoa plantations, gardens, shifting cultivation	Volcanic ash and tuffs; high volcanic island with considerable erosion causing hilly to deeply dissected landforms on central volcano, lava plateaus and small cones to east and west; 0-1 200 m
Tm21-2bc	Be			16	2 000-3 000 mm; 26°C	New Hebrides: Banks islands (Vanua Lava, Santa Maria, Mere Lava)	Rain forest; small population uses areas for coconuts and gardens	Recent volcanic materials; islands are high active volcanoes, landforms are hilly to deeply dissected; 0-1 400 m
Tm22-1/2abc		Xh		65	120-1 800 mm; 17-25°C	Hawaii: Hawaii	Grassland shrubs; now pasture, sugarcane, truck crops	Volcanic ash; coastal plain and uplands; 0-1 800 m
Tm24-3a	I R		Stony	14	4 000-5 000 mm; 25°C	Solomon Islands: Santa Cruz	Lowland forest; widespread areas of shifting cultivation for food crops	Recent volcanic ash over Pleistocene coral; raised coral platforms with variable ash cover from nearby volcanic sources; 0-5 m
To18-3bc	Th	Bf Fo	Stony	74	1 700-6 000+ mm; 26°C; weak dry season in west	Fiji: Koro, Taveuni, Lauthala, Nggamea	Forest; now subsistence cropping, coconut plantations	Basaltic flows, scoria and ash; lowlands and hills; 0-1 250 m
To19-2ab		Ah		75	1 400 mm; 14°C; 7.11	New Zealand: North Island	Scrub and fern; now dairying, intensive sheep farming, urban	Water-sorted volcanic ash, sandstone; down lands; 0-200 m
To20-2bc	Tv Th			513	1 400 mm; 13°C; 7.11, 7.51	New Zealand: North Island	Scrub and fern, some podocarp-mixed hardwood forest; now dairying, sheep farming, exotic forests	Volcanic ash; down lands, some hill and steep lands; 0-200 m
To21-2/3abc	Th			292	750-5 000 mm; 12-25°C	Hawaii: Hawaii	Trees, shrubs and grassland; now irrigated and nonirrigated crops, woodland, pasture	Volcanic ash; uplands; 0-2 400 m
To22-3abc	Bh Gh	Hh		40	500-5 000 mm; 13-25°C	Hawaii: Hawaii	Grassland and shrubs, forest; now pasture, woodland, some areas irrigated for crops	Basic igneous rock, volcanic ash; uplands; 0-1 700 m
To23-3abc	I	Ah Pg		75	500-8 000 mm; 14-23°C	Hawaii: Maui	Forest, scrub and grassland; now pasture, wildlife and water supply reserve, some cropping on lowlands	Basic igneous rocks, volcanic ash; mainly rough and mountainous uplands; 0-3 000 m

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Tv2-1ab				1 469	1 500 mm: 13°C: 7.11. 7.21. 7.51. 7.81	New Zealand: North Island	Scrub and fern. some podocarp-mixed hardwood forest; now some dairying. intensive sheep farming. exotic forest	Rhyolitic volcanic ash: down and hill lands. some steep lands: 0-1 000 m
Tv18-1c	Je	I	Stony	6	3 000-4 000 mm; 25°C	Solomon Islands: Savo. Tinakula	Disturbed lowland forest with extensive regrowth: shifting cultivation for food crops on lower slopes	Young volcanic ash and cinders from quiescent and active volcanic cones: 0-700 m
Tv19-1c	Bd			1 455	2 000 mm: 12°C: 7.11. 7.12. 7.51. 7.81	New Zealand: North Island	Beech. beech podocarp. podocarp-mixed hardwood forest: now forestry. extensive sheep farming	Volcanic ash. greywacke. mudstone. sandstone: steep and mountainous lands: 0-1 500 m
Tv33-abc	Re			9	3 000 mm: 25°C: nonseasonal	New Hebrides: Epi	Rain forest: few gardens on coast. rare coconut plantations	Volcanic ash: volcanic cones. plateaus and hills. flat to strongly dissected: 0-830 m
Tv34-1abc	To	I		5	2 000 mm: 27°C; moderately seasonal	Tonga: Late. Niuafo'ou. Tafahi	Forest and scrub: some gardening and copra production	Ash. lava and limestone: volcanic island with coral platform: 0-500 m
Tv35-1bc	Re	Hl Tm		6	1 900-2 000 mm: 23-25°C: moderately seasonal	Tonga: Fonualei. Toku. Kao, Tofua, Hunga Hapaii. Ate	Forest and scrub: subsistence cultivation on inhabited islands	Andesitic ash. in places still accumulating from active volcanoes: 0-1 000 m
Tv36-bc		Re Th		19	2 000-3 000 mm: 23°C	New Hebrides: Tana	Rain forest and bare lands on active volcano: coconut and coffee plantations. gardens	Formerly a volcanic crater. andesitic ash. scoria and agglomerate extensive: little coral limestone bordering east coast: 0-300 m
Tv37-1b	Re	Tm		30	3 000 mm: 25°C	New Hebrides: Ambrim	Rain forest: coconut and cocoa plantations. gardens. shifting cultivation	Basaltic ash: high volcanic island. coast more level with cliffs and beaches: 0-200 m
Vc1-3b				1 524	Summer-low. summer-medium. winter-medium: 4.2. 4.2211	Australia: eastern	Grasslands. shrublands. woodlands. forests. native pastures: now grazed	Mainly deep clay alluvia. but also sedentary on mudstones. siltstones and calcareous and feldspathic sandstones: undulating
Vc52-3a	Lk Ws	So	Sodic (Lk)[1]	57 518	Summer dominant-low. arid-summer dominant, summer-low. arid-summer. uniform-low. winter-low. arid-uniform: 1.4. 1.483. 1.484, 1.485. 1.533, 1.9. 3.2, 3.25. 4.2211, 4.3. 4.31. 5.7. 6.23. 6.24. 6.8. 6.834. 6.85	Australia: eastern. Northern Territory	Grasslands. shrublands. woodlands. forests: now grazed with some rice. cotton. sown pastures. feed crops	Mainly deep clay alluvia. but also sedentary on mudstones. siltstones. and calcareous and feldspathic sandstones: plains
Vc53-3a	Lk So	Ws	Sodic (Lk)[1]	19 721	Summer dominant-low. arid-summer dominant. arid-summer: 3.2. 4.2211. 4.3. 4.31	Australia: eastern. Northern Territory. Western	Grasslands, shrublands. woodlands: now grazed with some rice. cotton. sown pastures and feed crops	Mainly deep clay alluvia, but also sedentary on mudstones. siltstones. metasediments and limestones: plains
Vc53-3a	Lk So	Ws	Sodic (Lk)[1]		Summer dominant-medium: 1.485	Australia: Queensland	Woodlands; now grazed	Clayey alluvia: plains

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Vc53-3b	Lk So	Ws	Sodic (Lk)[1]	3 486	Arid-summer, summer-medium, summer-low; 3.2, 4.2211	Australia: eastern, Northern Territory, Western	Grasslands, shrublands, woodlands; now grazed	Mainly deep clay alluvia, but also sedentary on mudstones, siltstones, metasediments and limestones; undulating
Vc54-3a	Ao Ag			828	Summer dominant-low, arid-summer dominant; 1.542, 3.26	Australia: Northern Territory	Woodlands, shrublands: now grazed	Clayey alluvia; plains
Vc55-3ab	Hh Hl	Rc		42	400-1 200 mm; 23°C	Hawaii: Oahu	Shrubs, grassland; now sugarcane, truck crops, pasture, urban land, much fill land	Alluvium and colluvium, coral limestone coastal plain; 0-130 m
Vp1-3a				1 153	Uniform-low, summer-low, summer-medium, summer dominant-medium; 4.2, 4.21, 4.2211, 4.24, 4.32, 5.45, 5.7, 5.76	Australia: eastern	Grasslands; now a wide range of crops, pastures	Alluvium, mainly from basalt; plains
Vp1-3a			Saline	497	Winter-low; 6.23	Australia: South	Grasslands, shrublands, native pasture; now grazed	Alluvium; plains
Vp1-3b			Lithic	1 673	Summer-medium; 2.2, 4.2, 4.2211, 5.45, 5.7, 5.76, 6.2	Australia: eastern	Grasslands, woodlands, native pastures; now improved pastures and grain crops - mainly wheat, sorghum	Alluvium, mainly from basalt; undulating to hilly
Vp43-3a	Kh Oe		Petrocalcic	288	Winter-medium; 4.21, 6.2, 6.21, 6.23	Australia: South	Grasslands, woodlands, native pastures; some now improved, some cropping	Calcareous alluvium; plains
Vp57-3a	Hh		Lithic	1 709	Summer dominant-medium, summer dominant-low, summer-medium, summer-low; 4.2, 4.21, 4.2211, 4.31	Australia: eastern	Grasslands, woodlands, native pastures; grazed, some wheat and sorghum cropping	Mainly basalts; plains
Vp58-3bc	Hh Ne		Lithic	470	Summer-low, summer dominant-medium; 4.2, 4.21	Australia: eastern	Grasslands, woodlands, forests, native pastures; grazed	Mainly basalts; rolling to steep
Vp59-3a	Lo			186	Summer-medium; 4.24, 4.42	Australia: eastern	Grasslands, woodlands, native pastures; now some improved	Clayey alluvium from basalt; plains
Vp60-3a	Vc Gh	Zt		947	Summer dominant-high, summer dominant-medium; 1.4, 1.485, 1.9	Australia: Northern Territory	Grasslands, native pastures; grazed, some rice	Clayey alluvia; plains
We19-1/2b	Ws	Lc Lk Lf		1 156	Winter-medium, uniform-medium; 5.44, 6.5, 6.511, 6.531, 7.13, 7.24, 7.8	Australia: Tasmania	Forests, woodlands, native pastures; now some sown, forestry	Dolerite; hilly
Wh3-1a	Ws Ag	Ah P		76	Summer dominant-high; 4.83	Australia: Queensland	Woodlands, forests, native pastures; some now improved	Alluvium; plains
Ws15-1/2b	Lc So	Nd Ne Fr		331	Uniform-high, uniform-low, uniform-medium; 6.53, 6.833	Australia: eastern	Forests; now some grazed	Various rocks, including shales, metasediments, metamorphic and igneous rocks; undulating to hilly

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ws16-1/2c	I R	Lc		199	Uniform-medium. summer-medium: 4.2. 4.51. 6.1. 7.8	Australia: eastern	Forests: undeveloped	Various rocks. including shales. metamorphic and igneous rocks. metasediments: mountainous
Ws17-1/2b	So I	R		464	Summer dominant-low: 1.542, 4.31	Australia: Northern Territory	Woodlands: now some grazed	Shales. siltstones and sandstones: hilly
Ws18-1/2b	So Vc			474	Summer dominant-low. summer dominant-medium: 1.542. 3.26	Australia: Western	Woodlands: now some grazed	Colluvium and alluvium. mainly from shale; plains
Ws19-1/2b	So Wd	Lc	Stony (Wd.Ws) [1]	1 100	Winter dominant-low. winter dominant-medium: 6.1.6.183.6.1912	Australia: Western	Woodlands. forests: now sown pastures	Alluvium and colluvium. mainly from laterized gneisses and granites: undulating to hilly
Ws20-1/2a	So Lk	Lc Vp Vc		513	Summer dominant-medium. summer-medium. summer dominant-high: 1.483. 1.485. 4.2. 4.21. 4.42. 4.43. 6.2	Australia: eastern	Woodlands. forests: now some sown pastures	Alluvium: plains
Ws21-1/2b	I R	Lo Lc So		6 420	Summer-medium. summer dominant-medium. uniform-medium. summer-low. winter-low: 1.244. 1.485.4.2.4.21.4.2211. 4.4. 4.43. 5.4. 5.45. 5.7. 5.76. 6.192. 6.2. 6.23. 6.232. 6.53. 7.1	Australia: eastern	Woodlands. forests: now some sown pastures	Alluvium and colluvium: undulating to hilly
Ws22-1/2b	Wd Lk	So R	Stony	1 915	Winter dominant-low. winter-low. winter-medium. winter dominant-medium: 6.1, 6.183. 6.1922. 6.2	Australia: Western	Forests. woodlands: now sown pastures. wheat	Laterite: undulating to hilly dissected laterite plateaus
Ws23-1a	So Wd	P		265	Winter-medium; 6.2. 6.21	Australia: southeast	Woodlands. heaths: now some sown pastures	Alluvium: plains
Ws24-1b	So P	Lo		1 736	Winter-low. winter-medium. uniform-medium: 5.4. 5.7. 6.1924. 6.2. 6.23. 6.24. 6.8. 6.833, 7.12	Australia: southeast	Woodlands. heaths: now some sown pastures	Alluvium and colluvium: undulating to hilly
Ws25-1a	So P	Qa		242	Winter-medium: 6.21. 6.22	Australia: Western	Woodlands. heaths: now sown pastures	Alluvium: plains
Ws26-1b	So P			258	Winter-low: 6.1. 6.822. 6.834	Australia: Western	Woodlands. heaths: now sown pastures	Alluvial: undulating
Ws27-1a	P So	Vc		845	Winter-medium: 6.1922. 6.22	Australia: Western	Woodlands. heaths: now sown pastures	Alluvium and colluvium. mainly from granite: plains
Ws28-1b	P Qf	Qa So		189	Winter dominant-low: 6.1922	Australia: Western	Woodlands. heaths: now sown pastures	Alluvium and colluvium. mainly from granite: undulating
Ws29-1/2b	Wd	So I R		818	Summer-high. summer-medium; 4.4. 4.51	Australia: Queensland	Woodlands. forests: now grazed	Colluvium from various rocks. including granites. metasediments. sandstones. phyllites: hilly
Ws29-1/2b	Wd	So R I			Summer dominant-medium. summer dominant-high: 1.4. 1.5, 1.9	Australia: Northern Territory	Woodlands. forests: now grazed	Alluvium and colluvium. mainly from greywacke. siltstones and sandstones: hilly

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ws30-1/2b	Wd	Lo Lc I		9 859	Summer- medium. summer dominant-medium: 4.24. 4.4	Australia: eastern	Woodlands. forests: now grazed	Sedimentary. metamorphic. intermediate volcanic and granitic rocks: undulating to hilly
Ws31-1/2b	Wd	Lo Lc So			Summer dominant-medium: 4.4. 4.44	Australia: Queensland	Woodlands. forests: now grazed	Sedimentary. metamorphic. intermediate volcanic and granitic rocks: undulating to hilly
Ws31-1/2b	Wd	Lo Lc So			Winter-medium. winter-low. uniform-medium. uniform-high. summer-medium. summer dominant-medium; 1.132. 1.485. 1.924. 2.2. 4.1. 4.2. 4.21. 4.24. 4.4. 4.43. 4.44. 4.51. 4.52. 5.3. 5.4. 5.42. 5.44. 5.45. 5.76, 5.77. 6.2. 6.23. 6.5. 6.512. 6.53. 6.834. 7.1. 7.14. 7.24. 7.8	Australia: eastern	Woodlands. forests: now some sown pastures, some horticulture	Various rocks. including acid to intermediate igneous. sedimentary and metamorphic rocks: undulating to hilly
Ws32-1/2ab	Wd	So Yl Qc		199	Summer dominat-low. summer dominant-medium: 1.542, 1.914. 1.916. 3.26	Australia: Western	Woodlands: now grazed	Granitic rocks: flat to undulating with scattered rises
Ws33-1/2c	Wd	R I Lo		113	Summer dominant-medium; 4.2	Australia: eastern	Woodlands. forests: mainly undeveloped	Various rocks. including acid to intermediate igneous. sedimentary and metamorphic rocks: mountainous
Ws34-1/2a	Wd	So Ag Ao		861	Summer dominant-medium: 1.9	Australia: Northern Territory	Woodlands. forests: now grazed	Alluvium: plains
Ws35-1/2b	Wd	Lf Qa Qc	Stony (Ws.Wd)[1]	1 292	Winter dominant-medium: winter dominant-high: 6.1. 6.183. 6.2	Australia: Western	Forest: now sown pastures. wheat	Laterite: hilly dissected plateaus
Ws36-1b	Wd	So P Rd		2 163	Summer-low. summer-medium. summer-high. uniform-medium. winter-medium: 4.1. 4.2. 4.52. 5.4. 5.42. 5.45. 7.12	Australia: eastern	Woodlands. forests: now some sown pasture. some horticulture	Alluvium and colluvium. in part from granitic and/or sedimentary rocks: undulating to hilly
Ws36-1b	Wd	So Rd P			Uniform-medium. winter-medium: 6.5. 6.511. 6.531. 7.8	Australia: Tasmania	Forests: now sown pastures. some horticulture (apples)	Colluvium and alluvium. mainly from granites and sandstones: undulating to hilly
Ws37-1b	Wd	Lf Lp P		99	Winter-low: 6.21	Australia: South	Forests: now sown pastures	Laterite: undulating to hilly dissected plateaus
Ws38-1a	Wd	P Qa So		404	Winter-medium. winter dominant-high: 6.1. 6.183. 6.21	Australia: Western	Woodlands. forests. heaths: now sown pastures. wheat. oats and barley	Alluvium and colluvium associated with truncated laterite profiles: plains
Ws38-1b	Wd	P Qa So		745	Winter dominant-medium. winter dominant-low: 6.1922	Australia: Western	Woodlands. forests. heaths: now sown pastures. wheat. oats and barley	Alluvium and colluvium associated with truncated laterite profiles: undulating
Ws39-1a	Wd	Fr Fx Rd		421	Summer dominant-medium: 1.5. 1.532. 6.1922	Australia: Northern Territory	Woodlands: now grazed	Alluvium: plains

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC *(continued)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Ws40-1b	Wd	Rd		828	Summer dominant-medium, summer dominant-high; 1.4, 1.5, 1.9, 1.916	Australia: Northern Territory	Woodlands; now grazed	Colluvium and alluvium from granites; undulating to hilly with rock outcrops
Ws41-1/2b	So	Lk Lc	Sodic (L)[1]	248	Winter-low; 6.912, 6.1922	Australia: Western	Woodlands; now some sown pastures	Colluvium and alluvium, mainly from gneissic rocks; undulating
Ws42-1/2b	So	Lk Yh Yl	Sodic (Lk)[1]	205	Summer dominant-low; 3.26	Australia: Northern Territory	Woodlands; now grazed	Colluvium and alluvium from various rocks; undulating
Ws43-1/2a	So	Lk Vc	Sodic (Lk)[1]	981	Winter-low, winter dominant-low; 4.2, 6.1, 6.1922, 6.1923, 6.8, 6.822	Australia: Western	Woodlands; now wheat cropping, sown pastures	Alluvium; plains
Ws44-1/2b	So	Sg		1 232	Winter-low; 6.1, 6.1922	Australia: Western	Woodlands; now wheat cropping, sown pastures	Alluvium; undulating ridges
Ws45-1/2a	So	Lk Vp Vc	Sodic (Lk)[1]	818	Summer dominant-low, summer dominant-medium; 1.9, 4.2, 4.21, 4.2211, 4.31, 4.43	Australia: eastern	Woodlands, forests; now some sown pastures, some cropping	Alluvium; plains
Ws46-1/2b	So	Lk Lc Wd	Sodic (Lk)[1]	1 471	Summer dominant-low, summer dominant-medium, summer-low; 4.2, 4.21, 4.4	Australia: eastern	Woodlands, forests; now some sown pastures	Alluvium; undulating to hilly
Xh45-2a	Yh Yl Rd			212	Arid-winter dominant, arid-winter; 3.14, 3.2, 3.24, 3.25	Australia: Western	Shrublands; now grazed, with irrigation tropical fruits (bananas) and vegetables	Alluvium; plains
Xh46-2b	I Qf Rd			166	Arid-winter; 3.14, 3.2, 3.26	Australia: Western	Shrublands; now some sparsely grazed	Limestones; hilly with rock outcrops
Xk30-2a	Yh Rc	Yl	Sodic(Xk), lithic(Xk)[1]	17 537	Arid-winter, arid-uniform, arid-summer dominant, arid-summer; 3.2, 3.26	Australia: Western, central	Shrublands; now some sparsely grazed	Highly calcareous rocks such as calcretes, limestones, calcareous shales; plains
Xk31-2b	I Xh	Vc	Sodic(Xk), lithic(Xk)[1]	1 212	Arid-uniform, arid-summer; 3.14, 3.2, 3.23, 3.26, 6.8	Australia: Western, Northern Territory	Shrublands; now some grazed	Highly calcareous rocks such as calcretes, basic igneous rocks, limestones, calcareous shales; hilly with rock outcrops
Xk38-2b	I R	Xh Rc So	Sodic(Xk). lithic(Xk)[1]	6 334	Arid-winter, arid-uniform, winter-low; 3.2, 3.24, 3.4, 3.43	Australia: southern	Shrublands; now some grazed	Highly calcareous rocks such as limestones, calcareous shales; hilly with rock outcrops
Xk39-2b	Xh Yl	I R	Lithic (Xk)[1]	596	Arid-summer dominant, arid-summer; 3.2	Australia: central, Queensland	Shrublands; now some sparsely grazed	Limestones and highly calcareous sedimentary rocks; undulating ridges
Xk40-1/2b		Rc So Lk Ws	Sodic(Lk)[1]	29 301	Arid-uniform, arid-winter, winter-low, uniform-low; 3.2, 3.24, 3.25, 6.1, 6.1912, 6.1913, 6.8, 6.822, 6.833, 6.834	Australia: central	Shrublands; now some improved pastures, mixed farming, wheat, horticulture and viticulture under irrigation	Highly calcareous terrestrial sediments; undulating with dunes
Xk41-2b	Xh Lk	So	Lithic(Xk) sodic(Lk)[1]	384	Winter-low; 6.1923, 6.883	Australia: central	Shrublands; now some improved pastures, mixed farming, wheat	Highly calcareous terrestrial sediments; hilly with some rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Xk42-1/2ab	So Yl	Lk Vc Rd	Sodic(Lk)[1]	10 789	Arid-uniform. arid-winter. winter-low: 3.14. 3.2. 3.23. 3.24. 6.1. 6.8. 6.812. 6.834	Australia: Western	Shrublands: now some improved pastures, mixcd farming. wheat	Highly calcareous terrestrial sediments: flat to undulating with some rock outcrops
Xk43-1/2a	Zg Zo	Lk So Vc	Sodic	152	Arid-summer: 3.26	Australia: Western	Shrublands: now grazcd	Highly calcareous terrestrial sediments: plains
Xk44-1/2ab	Rc Yl	So	Lithic(Xk)	242	Arid-summer; 3.2	Australia: central	Shrublands; now grazed	Limestones: gently undulating to hilly
Xk45-2a	Rc Z			606	Arid-summer dominant; 1.5. 1.913. 4.2211	Australia: northwest coast	Shrublands. woodlands. grasslands: now grazed	Calcareous sediments; plains
Xk46-2ab	Xh Hh	Vc Yl So	Lithic(Xk)	603	Arid-summer dominant. arid-summer; 3.2	Australia: central	Shrublands: now grazed	Limestones; flat to undulating. some rock outcrops
Xk47-2b	Xh	Yh Lk Vc	Sodic(Lk)[1]	2 763	Arid-summer dominant. arid-summcr: 3.1. 3.2, 3.26	Australia: Western	Shrublands: now some sparsely grazed	Basic lavas. dolomites; steep ranges with rock outcrops
Xk48-2b	Xh	I R Vc		2 312	Summer dominant-low: 1.5. 3.1. 3.14. 3.2. 3.26	Australia: northern	Woodlands. grasslands: now some sparsely grazed	Intermediate and basic igneous rocks and limestones: undulating to hilly with rock outcrops
Xk49-2a	Xh	Vp Rc		195	Winter-low: 6.2	Australia: South	Shrublands: now some improved pasturcs. some wheat	Limestones. calcretes: plains
Xk50-2b	Xh	Kh Re So Rc	Lithic (Kh)[1]	166	Winter dominant-low: 6.232	Australia: South	Shrublands; now some grazcd	Limestones. calcretes; undulating broken terrain. some calcrete outcrops
Yh32-2a	Qf Yl		Duripan	15 768	Arid-uniform. arid-summcr, arid-winter: 3.2, 3.24. 3.25. 3.26	Australia: Western	Shrublands: now grazed	Colluvium over red-brown hardpan. associated with granites and gneisses: plains and gently undulating
Yh32-2a	Qf Yl		Lithic(Yh)	590	Arid-summer dominant: 3.26	Australia: Western	Shrublands: now sparsely grazed	Colluvium. possibly from remnants of old laterite profiles, overlying granite; plains. rock outcrops
Yh33-2b	I Yl	So	Duripan	2 948	Arid-uniform. arid-summer: 3.2. 3.23. 3.24. 6.8	Australia: Western	Shrublands: now grazed	Colluvium over red-brown hardpan. associated with granites. gneisses and metasediments: ridges and hills. some hard block laterite
Yh34-2ab	Yl Lk	So	Duripan (Yh). sodic(Lk)[1]	686	Arid-summer: 3.2. 3.26	Australia: Queensland	Shrublands: now grazed	Colluvium on red-brown hardpan: undulating to hilly. silcrete boulders
Yh35-2bc	I R	Lk So	Lithic. sodic(Lk)[1]	9 408	Arid-summer dominant. arid-summer: 3.1. 3.2. 3.23, 3.26	Australia: Western	Shrublands. grasslands: now sparsely grazed	Basic igneous rocks and sediments from old laterite profiles: steep ranges with rock outcrops
Yh36-2a	Lk So	Yl	Sodic(Lk)[1]	828	Arid-summer dominant; 3.26	Australia: Western	Shrublands: now sparsely grazed	Alluvium: plains
Yh37-2a	Yl Lc	Ws Vc I	Lithic	338	Summer dominant-low. arid-summer dominant. summer dominant-medium: 1.9, 4.3	Australia: central. Queensland	Shrublands. woodlands: now sparsely grazed	Colluvium. probably from old laterite profiles; gently undulating with rock outcrops

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Yh38-2b	I R	Yl Lc Ws	Lithic	3 213	Arid-summer. arid-summer dominant. summer dominant-low: 3.2. 3.26. 4.3	Australia: central	Woodlands. shrublands: now sparsely grazed	Various rocks such as granites. basic rocks. remnants of old laterites: hilly with rock outcrops
Yh39-3a	Vc			785	Arid-summer dominant: 3.26	Australia: Western	Shrublands: now grazed	Clayey alluvium: valley plains
Yl21-1/2a	Qf Yh	Rd Lk So	Duripan (Yl). sodic (Lk.Lc)[1]	61 235	Arid-summer. summer-low. arid-uniform. arid-summer dominant. summer dominant-low. uniform-low. summer dominant-medium. arid-winter dominant. arid-winter: 1.5. 1.542. 1.9. 1.916. 3.14. 3.2. 3.23. 3.24. 3.25. 3.26. 4.2. 4.2211. 4.31. 5.76. 6.1. 6.8. 6.812. 6.833.6.834	Australia: central	Grasslands. woodlands. shrublands: now sparsely grazed in drier areas. improved pastures. cereals where wetter. specialty crops with irrigation	Siliceous rocks. including granites. granodiorites. sandstones. acid volcanic rocks. marine limestones. unconsolidated sandy sediments: plains. some dunes
Yl22-1/2b	I R	Yh Lk So	Duripan (Yl). sodic (Lk.Lc)[1]	31 987	Arid-summer. summer-low, arid-uniform. arid-winter. summer dominant-low. summer dominant-medium. uniform-low. arid-summer dominant: 1.1. 1.485. 1.5. 1.532. 1.542. 1.9. 1.914. 1.916. 3.1. 3.2. 3.24. 3.26. 4.2. 4.3. 5.76, 6.8	Australia: central	Shrublands. grasslands. woodlands: now sparsely grazed in drier areas. improved pasture. cereals where wetter. specialty crops with irrigation	Siliceous rocks. including granites. granodiorites. sandstones. acid volcanic rocks. marine limestones. unconsolidated sandy sediments: plains. some dunes
Yl23-1b	Qf Qa	I R		3 776	Winter-low. arid-winter. winter dominant-low. arid-winter dominant: 6.1. 6.1922. 6.1923. 6.8. 6.812. 6.822	Australia: Western	Woodlands. shrublands: now some improved pasture. cereals	Mainly granitic rocks: undulating. some scarps. some rock outcrops
Yl24-1/2a	Ws So	Lc Fx Ao		3 882	Summer dominant-low. summer dominant-medium: 1.5.1.9. 1.916. 3.1. 4.2. 4.2211. 4.3. 4.31	Australia: Northern Territory. eastern	Woodlands: now some improved pasture	Siliceous rocks. including granites. granodiorites. sandstones. acid volcanic rocks. marine limestones, unconsolidated sandy sediments: plains. some rock outcrops and hardened block laterite
Yl25-1/2b	I R	Fx Lc Ws		1 911	Summer dominant-low. summer dominant-medium. uniform-medium, summer-medium: 1.542. 1.916. 5.7. 5.72. 5.76	Australia: Northern Territory. eastern	Woodlands: now some improved pasture	Siliceous rocks. including granites. granodiorites. sandstones. acid volcanic rocks. marine limestones. unconsolidated sandy sediments: undulating to hilly with rock outcrops
Yl26-1/2a	Lk So	Vc Rd	Sodic(Lk)[1]	802	Summer dominant-low: 3.26	Australia: Western	Woodlands: now grazed	Siliceous rocks. including granites. granodiorites. sandstones. acid volcanic rocks. marine limestones. unconsolidated sandy sediments: plains with rock outcrops
Yl27-1/2a	Ao Ag	Fx Ah		1 839	Summer dominant-medium. summer dominant-high. summer dominant-low: 1.4. 1.484. 1.9. 4.3	Australia: Queensland	Woodlands: now grazed	Alluvium and colluvium from laterite areas: plains

See notes at end of table.

TABLE 10. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR AUSTRALASIA AND THE PACIFIC (*concluded*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Yl28-1a	Rd So	Vc Xk		331	Arid-summer, summer-low: 3.26, 4.221	Australia: New South Wales, Queensland	Woodlands: now grazed	Alluvium: plains, some dunes
Zo36-2a	Zg	Rd Rc Xk Yh		14 099	Arid-uniform, arid-summer, arid-summer dominant, winter-low, winter dominant-low, arid-winter, arid-winter dominant: 3.1, 3.2, 3.23, 3.24, 3.25, 3.26, 6.1, 6.1922, 6.1923, 6.8, 6.812, 6.822	Australia: central, Western	Grasslands, shrublands: now some grazed, mainly undeveloped	Alluvial sediments: valley plains and playas
Zt5-3a	V R			1 143	Summer dominant-medium, summer dominant-low, summer dominant-high, arid-uniform: 1.5, 1.914, 1.916, 3.14	Australia: northern	Grasslands, shrublands: now some sparsely grazed	Alluvium: coastal plains
Zt6-3a	V Ws	So		1 325	Summer dominant-medium, summer dominant-high, summer-medium: 1.4, 1.483, 1.484, 1.485, 1.9, 1.916, 1.924, 1.925, 4.1, 4.42, 4.43	Australia: northern	Grasslands, shrublands: now some sparsely grazed	Clayey saline alluvia: coastal plains

[1] The phase applies only to the soil shown in brackets. — [2] The phase applies only to part of the association.

2 500 mm in the south to 5 000 mm in the north. The vegetation is lowland rain forest, with some grassland. The soils are dominantly Ferric Acrisols with fine textures on moderate slopes. Where the land is steeper and more strongly dissected Ferralic and Dystric Cambisols occur, while Plinthic Acrisols are found on flatter, poorly drained surfaces. Fluvisols and Histosols occupy the associated floodplains. The soils are strongly weathered and leached and are generally of low fertility.

At lower elevations, along the coasts and extending far inland along the main rivers, are alluvial plains. Here swamp vegetation grows on recent alluvium. The soils are fine-textured Fluvisols, with Histosols in the areas with poorer drainage.

A further lowland area occurs south of the Fly river. Gently undulating plains between sea level and 50 m altitude are formed of deeply weathered Pleistocene sediments. The climate is strongly seasonal, with a long, relatively dry season and a short very wet one in which the land is inundated. The vegetation is mainly savanna and grassland, with swampland on the floodplains. The soil pattern reflects strong weathering and the wetness of the low-lying flats. Acrisols are dominant, with plinthic or gleyic horizons. Fluvisols and Gleyic Phaeozems are also recorded.

The lowest parts of the lowlands are found in relatively small areas of tidal mangrove swamp under 20 m in altitude. The soils are saline phases of Eutric Histosols and Eutric Gleysols.

PAPUA NEW GUINEA MOUNTAINS

The Central Cordillera of Papua New Guinea is continuous from the Irian Barat border in the west to the Owen Stanley range in the southeast. It includes broad intramontane plains at altitudes of 1 500 to 1 800 m, separating mountain ridges of up to 4 300 m. Another smaller mountain chain in the north continues east into the mountains of New Britain. Temperatures are high at lower altitudes, decreasing in the mountains, and rainfalls are high. Vegetation is principally lower montane forest with some grassland, and at high altitudes some montane forest and alpine vegetation. The geological pattern is complex, with Mesozoic (some metamorphosed) and Tertiary limestones, volcanics, siltstones and sandstones extensive. The topography above the valleys is characteristically steep and mountainous.

The soil pattern reflects the environmental factors in the dominance of weakly developed soils. Dystric Cambisols are probably the most extensive, and they are commonly associated with Humic Cambisols, Regosols, Lithosols, Rankers and Rendzinas. Smaller areas of Histosols and Andosols also occur. More developed soils are represented by the Acrisols, which are dominant in parts of the Central highlands and common as subdominants or inclusions throughout the region.

Northern New Zealand

The northern peninsula of New Zealand is a region of mixed stratigraphy and highly varied vegetation and topography. It differs from other parts of the country in its climate, which is characteristically warm — approaching subtropical — and humid. Weathering is therefore stronger and soils tend to be fine textured, strongly leached and well developed.

All the soil-forming factors have been used in explaining the intricate soil pattern, and in classifying the large number of soil units that have been recognized in soil surveys. Soil development sequences in "suites" of soils on similar parent material have proved of particular value in predicting agricultural responses. Vegetation differences have shown clearly in the soil patterns, the kauri (*Agathis australis*) being outstanding in its ability to cause podzolization.

The most extensive soils are Acrisols, with Humic, Orthic and Gleyic suborders all well represented. On steep slopes, and on some coastal sands where the time of soil formation has been short, Cambisols occur. In the coastal associations these grade into Regosols towards the sea, and into Podzols where kauri forests have occurred inland. Strong Podzol development also occurs on finer sedimentary rocks under kauri forests in other parts of the peninsula. On basic volcanic rocks the soil development sequence includes Mollic Andosols in the first stages of weathering, Humic Acrisols, and, in the final stages, Orthic Ferralsols with ironstone concretions.

New Zealand volcanic plateau

The western and central parts of the North Island of New Zealand are dominated by volcanic activity. The central plateau, rising to over 1 000 m in altitude, is composed of ignimbrite that erupted in vast quantities — estimated as 8 000 cu km — in the early Pleistocene. The surface was later buried under deep layers of rhyolitic pumice and other rocks. A large number of deposits from events of the last 40 000 years have been mapped. Several of these, including the Taupo pumice eruptions 1 700 years ago, have exceeded 50 cu km in volume, have covered large areas with deep deposits and have initiated new cycles of soil formation. New cycles of vegetation development have also been started by the large eruptions as great areas of forest were destroyed. After the latest eruptions burning by the Maoris restricted forest regeneration, and the soils have developed in many areas under scrub and fern. The climate is mild, with mean annual temperatures of 12°C and well-distributed rainfalls totalling between 1 000 and 2 000 mm. The soils are dominated by Andosols. Where Taupo pumice is soil forming, textures are coarse and topsoils thin, resulting in Vitric Andosols. In the west, andesitic ash from Mount Egmont has formed dominantly Humic Andosols, while on the northwestern periphery of the plateau Ochric Andosols are more common. The rapid weathering out of allophane is a dominant property that strongly affects their utilization. Soils derived from volcanic ash extend widely beyond the plateau, but as the surrounding areas are often mountainous, with high rainfall, erosion has prevented the development of extensive areas of Andosols and the soil pattern is usually a complex of Cambisols and Andosols. Regosols from volcanic ash have been mapped around the currently active centres and where eruptions have occurred within the last 200 or 300 years.

outhern and central New Zealand

New Zealand south of latitude 40°S is a zone with wide variations in climate, vegetation and topography, but the uniformity of composition of the parent rocks and the youthful nature of the landscape give it unity. The climate is temperate with a strong marine influence. The rainfall pattern is governed by the high axial mountain range which lies across the prevailing moist westerly winds. Western and mountain regions are superhumid, while intermontane basins and eastern plains are subhumid. The vegetation includes forest in the wetter areas, with podocarps, mixed hardwoods and *Nothofagus* species, and tussock grasslands in the seasonally dry lowlands and in the mountains. The core of the main ranges is made up of greywackes and schists. The ranges are often flanked with sedimentaries, and many areas are mantled with Quaternary loess and solifluction deposits.

The topography, apart from relatively small areas of plains and downlands, is steep and mountainous. The soils, while diverse, are therefore youthful, and Cambisols predominate. Associated with Cambisols in the mountains are extensive areas of Podzols and Lithosols, while on the lowlands, particularly on loess, argillic horizons and fragipans have developed and Luvisols and Acrisols are found. It is probable that Phaeozems were more extensive before the soils were depleted by continuous cropping in the early days of European settlement. The

Cambisols of the steeplands have also suffered severely from the burning and overgrazing of the natural tussock vegetation, and many now classed as Dystric were probably originally Humic.

COMPLEX HIGH ISLANDS OF THE WESTERN PACIFIC

The islands of the western ocean margin include the Solomon Islands, New Hebrides, New Caledonia, and the islands of the Bismarck archipelago of Papua New Guinea.

These large islands are formed from crustal folds in which continental type rocks may be brought to the surface. The mountains are high and steep and many are volcanoes, some of which are still active. Lowlands, which include many raised coral platforms, are important in land use, but their area relative to the total land area is not high. The natural vegetation is dense evergreen rain forest with heavy undergrowth. It contains a large number of species. Under the influence of man, forest is giving way to scrub and grassland, often to the accompaniment of soil degradation and erosion. Total rainfalls are generally high and storms may be intense.

The soil pattern reflects the diversity of the landscape and many soil groups are found. In New Britain, for example, Rendzinas on limestone rocks are associated with Luvisols, Lithosols and Regosols. These soils also occur on igneous and sedimentary rocks, but Cambisols are dominant and Rankers, Acrisols and Fluvisols are found as well. In volcanic areas the soils are Andosols associated with Cambisols and Lithosols. Around the coasts Fluvisols, Histosols and Gleysols are formed on alluvium and Luvisols, Rendzinas and Fluvisols on coral sands.

In the Solomons the dominantly volcanic mountains are high and steep, and the soils include large areas of Chromic Cambisols, Regosols and Lithosols. Always associated with these, and in some areas dominant, are Orthic Ferralsols. Ferralic Cambisols, Nitosols, Andosols, Acrisols, Rendzinas and Phaeozems are locally important, and in coastal areas and on floodplains associations are similar to those in New Britain.

In New Caledonia, because of diverse environmental influences, the soil pattern is highly variable. In the east and in the central mountains, under very high rainfall, soils are generally red and unsaturated, but because of active erosion Cambisols and Regosols are more widespread than Ferralsols. On the drier west coast, soils are less leached and eroded. Parent rocks are also varied, and soils range from Acrisols and Podzols on siliceous rocks to Acric Ferralsols on ultrabasic rocks. The varied topography, ranging from flat to mountainous, further contributes to the complex distribution of soils.

OCEANIC HIGH ISLANDS

The oceanic high islands occur throughout the Pacific basin, either singly or in groups. They are the peaks of mountains or mountain ranges of basaltic lava which have risen above the ocean surface. They vary in area from a square kilometre or so to over 10 000, and in height from a few metres to over 4 000. Typically they have a central volcanic core, often steep and rugged, surrounded by a narrow belt of lowlands and frequently an uplifted coral coastal plain. The volcanoes may still be active. On some islands there are no lowlands; on other, larger islands the lowlands may be extensive and include river valleys with alluvial plains. The vegetation was largely rain forest, often with timber trees, but shifting cultivation and burning are increasing the areas of scrub and grassland, particularly where dry seasons occur. Climates are very favourable for plant growth, with high uniform temperatures and in most areas abundant, well-distributed rainfall.

The soil maps often show a concentric pattern of soils, with Cambisols on the steep central core and Regosols on the coral platforms. Lithic phases are extensive. Depressions behind the rim of the platform may be occupied by Gleysols. On older cores the slopes may be more gentle and the basalt deeply weathered to produce Ferralsols. Examples of all these may be found in the southern Cook Islands. Where volcanoes are still active, or were recently active as in the islands of Tonga, Andosols are added to the assemblage. A simpler pattern occurs on the islands such as Pitcairn which rise high straight from the sea. These have no coral, and apart from the Lithosols of the steep cliffs the soils are all Cambisols.

Upolu and Savai'i in Western Samoa are representative of the large high islands.

OCEANIC LOW ISLANDS

Innumerable coral atolls are scattered through the tropical Pacific. Seldom more than a few metres above sea level, they are composed of dead coral rubble thrown up by the sea on coral reefs growing on submerged sea mounts. Unless built up by accessions of volcanic ash or floating pumice, the pure coral is a poor medium for plant growth and the natural vegetation has few species. These do, however, include the valuable coconut. Skilled gardening by the inhabitants has extended the range of plants that can be grown and some atolls are able to support considerable populations.

The soil pattern is usually simple, being dominated by Calcaric Regosols, often with stones. Moist hollows are valuable sites for cropping, but the impress of the higher moisture levels on the soil profile is slight. More important, perhaps, is the build-up of organic matter in gardens by composting, although the total area of such man-made soils is small. Accessions of volcanic material could add some diversity to the soil pattern but examples are probably rare.

The oceanic low islands also include raised coral islands. These are often of the same form as atolls, more or less circular in shape with a flattish centre and a raised rim, but raised high above sea level. The surface may be very irregular, with coral pinnacles jutting up from a lagoon floor, as on Niue, or it may be smoothed over by deep deposits of volcanic ash, as on Vava'u, Tonga. Many of the raised islands have volcanic deposits, or, in places, deep ocean sediments, and these have given them a soil pattern more varied than that of the atolls. Lithosols, Rendzinas, Cambisols, Andosols, Nitosols and Ferralsols are commonly included in the soil associations.

6. NOTES ON SOIL CHARACTERISTICS, DISTRIBUTION AND LAND USE OF IMPORTANT SOIL UNITS

A. Acrisols

Af. FERRIC ACRISOLS

Soil characteristics. Ferric Acrisols in Papua New Guinea, the Solomon Islands and New Caledonia have texture contrast profiles with medium- to fine-textured A horizons and heavy clay argillic B horizons. The A horizons are very dark greyish brown to dark grey, the B horizons are yellowish brown to reddish brown with many iron mottles or iron concretions.

Distribution. These soils are widespread in the southeast and very extensive in the southwest lowlands of Papua New Guinea. In the Solomon Islands they occur over small areas of lowland terraces in the drier parts of northern Guadalcanal. In New Caledonia they are found over larger areas, mainly near the west coast. Rock types vary; in the Solomons and the Papua New Guinea lowlands they are formed on deeply weathered Pleistocene sediments, in the mountains they are found on andesitic rocks. In New Caledonia they occur on acid rocks — rhyolite, phtanite, schist and sandstone.

Land use. In Papua New Guinea they may be used for tree crops or pasture; in the other areas the natural pasture is grazed or forest used for shifting cultivation. They are under fire disclimax grasslands in the Solomons, but attempts are being made to plant some areas with oil palm.

Ag. GLEYIC ACRISOLS

Soil characteristics. Gleyic Acrisols in Australia are distinguished by texture profiles that become increasingly clayey with depth, and colour profiles that show evidence of periodic waterlogging in the B horizons. The coarse- to medium-textured A horizons range from brown and grey-brown to brownish grey and grey, and usually grade into paler E horizons that may be bleached. These horizons are gradually to clearly separated from the argillic B horizons in which light grey to light grey-brown and light olive-brown predominate, usually with bright yellowish and reddish mottles. Textures vary from medium to fine (sandy clay loams to medium clays) and the soil material is either massive and porous or has a blocky structure. Ironstone nodules occur frequently through the profile. Shallow gravelly profiles grade into weathered rock at depths of 45 to 75 cm, while deeper profiles grade into stratified alluvium or abruptly overlie remnants of buried soils. They are mildly to strongly acidic soils, with a low base saturation, and include the Gn 2.84, Gn 2.94 and Gn 3.04 soils of the Factual Key.[1]

In New Zealand Gleyic Acrisols are not as strongly weathered and leached as in Australia. The argillic horizons have less clay and the base saturations are low to medium. Luvisols may occur in the associations and Cambisols are found on steeper slopes. Most overlie a fragipan which is sufficiently impermeable to allow gleying even at rainfalls of less than 1 000 mm. They occur mainly in the southern yellow-grey earth group.

Distribution. Gleyic Acrisols are widespread in the humid areas of eastern, northern and southwestern Australia, principally on plains but also on hill slopes on alluvia and colluvia derived from sedimentary and lateritized rocks.

In New Zealand they occur on rolling to hilly loess-covered downlands in the east and south of the South Island.

Land use. In Australia the more extensive areas in the north are used mainly for cattle grazing of inferior native pastures at low stocking rates. Improved pastures in the southern areas, developed by the application of large amounts of phosphatic fertilizers, are used for more intensive cattle grazing.

In New Zealand, most areas have been converted to high-quality pastures under intensive sheep farming. Some cash cropping may also be included, but the tendency of the soils to erosion limits this use to easier sloping land.

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[1] K.H. NORTHCOTE. *A factual key for the recognition of Australian soils.* CSIRO Australia Division of Soils. Divisional Report 4/60. 3rd ed. 1971. CSIRO, Australia. Glenside, South Australia, Rellim Technical Publications. 123 p.

Ah. HUMIC ACRISOLS

Soil characteristics. Humic Acrisols in Australia are distinguished by texture profiles that become increasingly clayey with depth.

The medium-textured A horizons range from brown to grey or even black. They often grade into paler E horizons. These horizons have a gradual to clear boundary with the argillic B horizons in which brownish and yellowish colours predominate, and blocky to polyhedral structures are moderately to strongly developed.

Textures are usually medium to heavy clays in the deeper B horizon. They are deep soils, characteristically more than 1 m deep to C horizons of weathered rock, but profiles as shallow as 50 cm occur and are sometimes underlain by D horizons of light to heavy clays. These are mildly to strongly acidic soils with a low base saturation, and include Gn 3.51, Gn 3.54, Gn 3.71 and Gn 3.91 soils of the Factual Key.

In Papua New Guinea, Humic Acrisols are strongly acid, leached, porous silty clay to heavy clay soils. They have very dark A1 horizons merging into brown B horizons with only a slight increase in clay content.

In New Zealand they occur mainly in the brown granular clay group.

Distribution. Humic Acrisols occur in the humid lands of northwestern Tasmania and eastern and northern Australia, on terrain ranging from plains to hills and mountains. They are developed on a variety of rocks such as mudstones, shales, phyllites, feldspathic sandstones and granites, and alluvia derived from these.

In Papua New Guinea they are found principally in the highlands, on sedimentary rocks and old volcanic ash deposits.

In the warm humid north of New Zealand they are best developed on andesitic basalt, although they also occur on weathered volcanic ash deposits. The land is usually hilly to steep, with Eutric Cambisols occupying the steep slopes.

Land use. In Australia these soils are used mainly for sparse grazing of beef cattle in northern areas, while more intensive grazing of improved, highly fertilized pastures is practised in southern areas. There are also valuable stands of hardwood forests. In smaller areas specialty crops such as green beans and sugarcane may be grown.

In Papua New Guinea there is scope for tree crops such as coffee or tea, and possibilities for pasture development. Arable cropping on flatter land is limited by low soil fertility. Pyrethrum is grown at higher altitudes (2 000-3 000 m).

In New Zealand the steep lands are in forest or partially cleared for extensive sheep grazing. The downlands have been cleared and developed for intensive dairy and sheep farming.

Ao. ORTHIC ACRISOLS

Soil characteristics. Orthic Acrisols in Australia are distinguished by texture profiles that become increasingly clayey with depth, and colour profiles that are often strongly differentiated.

The coarse- to medium-textured A horizons range from brownish grey and dark grey to yellow-grey and grey-brown, and grade into paler E horizons that may be bleached. These horizons are gradually to clearly separated from the argillic B horizons in which yellow colours are conspicuous. Textures are commonly medium to medium fine (sandy clay loams and sandy clay to light clay) in these massive porous B horizons that often overlie remnants of earlier soils. Since many of these soils have formed on depositional sandy sheets, the thickness of the solum varies widely from 35 cm to 2 m. Segregations of iron to form firm earthy or brittle reddish nodules are fairly common, as also are lateritic fragments and other gravels. They are mildly to strongly acidic soils with a low base saturation, and include the Gn 2.74, Gn 2.34 and Gn 2.64 soils of the Factual Key.

In New Zealand they are classified as northern yellow brown earths and podzolised yellow-brown earths, strongly weathered and strongly leached soils from sedimentary rocks.

Distribution. Orthic Acrisols are widely distributed in the more humid or seasonally humid areas of eastern and northern Australia from Sydney to Darwin, on undulating plains, in valleys, and on rolling to low hilly terrain.

In New Zealand they occupy most of the northern peninsula. The land is typically hilly and steep, and was covered with dense podocarp-mixed hardwood forest.

Land use. The more extensive areas in Australia are used for cattle grazing on low-quality natural pastures at very low stocking rates, but improved high-quality pastures can be grown with high rates of fertilizer application, as on the coastal lowlands north of Brisbane. A wide range of specialty crops and vegetables (for example, citrus north of Sydney) may be grown with adequate fertilization in areas of suitable rainfall.

In New Zealand some areas are still in forest, but most have been cleared and developed into sheep farms.

Ap. PLINTHIC ACRISOLS

Soil characteristics. Plinthic Acrisols in Papua New Guinea are characterized by a pronounced increase in clay content with depth. The coarse- to medium-textured A horizon is mainly poorly developed, and often grades into a paler E horizon. The B horizon consists of a strongly red, grey and brown mottled clay to heavy clay layer, containing variable amounts of pisolitic iron concretions. These soils have a strongly acid reaction.

Distribution. Plinthic Acrisols are widely distributed on the flat to slightly undulating terrain of southeast Papua New Guinea, which has strongly seasonal climates.

Land use. This terrain is subject to inundation during the wet season. It has some potential for paddy growing and pasture.

B. Cambisols

Bc. CHROMIC CAMBISOLS

Soil characteristics. Chromic Cambisols in Australia have uniform medium-textured profiles, with organic surface horizons overlying reddish or brownish subsoils. The 01 horizon is 1 to 3 cm thick, and consists of a surface litter of undecomposed or partially decomposed twigs, bark and leaves matted with mosses, living grass and roots. Below this is the 02 horizon of black to very dark brown fibrous organic material. It is 2 to 5 cm thick, but is very irregular due to roots and embedded boulders. It sharply overlies the colour B horizon, which is red-brown, brown or yellow-brown loam or clay loam. It is very friable and its structure, which may be granular or blocky at the beginning, becomes massive with depth. Thin ironpans may be present. Texture usually becomes slightly coarser in the yellowish or greyish C horizon. Gravel, stones and boulders occur throughout the profiles of these permeable acid soils. They are the Um 7.12 soils of the Factual Key.

In the Solomon Islands, profiles typically have brown to very dark brown fine-textured topsoils overlying yellowish red or red stony subsoils.

Distribution. Chromic Cambisols are restricted in Australia to the alpine and subalpine tracts of Tasmania, and occur both on rocks weathered *in situ* and on colluvium. The main parent rocks include granites, gneisses, basalts and dolerites.

In the Solomon Islands they are widespread and extensive, being commonly found on hilly and steep land on volcanic parent materials.

Land use. The larger areas in Tasmania remain under natural grassland, woodland, forest or heath. In the past they have been used mainly for the summer grazing of sheep and cattle. This practice is now restricted in order to conserve the alpine and subalpine areas, as they provide the chief source of water for irrigation and the generation of hydroelectric power.

In the Solomon Islands most areas are under lowland forest and are used for shifting cultivation for food crops.

Bd. DYSTRIC CAMBISOLS

Soil characteristics. Dystric Cambisols in Papua New Guinea have uniform medium- to fine-textured profiles. They have moderately to weakly developed A horizons overlying yellowish brown to olive-brown B horizons. Their soil reaction is acid to weakly acid.

Distribution. Dystric Cambisols are very common throughout the mountain areas of Papua New Guinea. They occur on sedimentary, metamorphic and igneous rocks.

Land use. Difficult terrain limits agricultural development. In the less steeply sloping areas pastures offer the greatest potential.

Be. EUTRIC CAMBISOLS

Soil characteristics. Eutric Cambisols in Australia have uniform medium-textured profiles with colour or colour/structure B horizons. The Au1 horizons vary from black to brown or dark reddish brown loams, silt loams, clay loams or silty clay loams, and gradually pass into paler, but not bleached, Au2 horizons which in turn pass into brown or red-brown B horizons of loam or clay loam texture. The soil material is generally friable when moist but tends to be hard, massive and porous when dry, although some B horizons have a good blocky structure. Generally these soils range in depth from 60 cm to 1 m and overlie C horizons of weathered rock, stratified alluvium or horizons of buried soil materials. They are mildly to moderately acid soils and include the Um 4.21, Um 4.22 and Um 4.31 soils of the Factual Key.

In New Zealand they occur in a number of soil groups, usually as the most weakly developed member, and where some factor such as base-rich parent material, weak leaching, or steep slopes maintains high levels of percentage base saturation. Horizon differentiation is usually weak. In the New Hebrides they are also found on basic rocks and on steep slopes.

Distribution. Eutric Cambisols occur in the humid areas of eastern Australia on undulating, hilly or mountainous land or on river terraces. Their most common parent materials are schists, siltstones, acid to intermediate volcanics, shales, and alluvia derived from these rocks.

In New Zealand they are found in the north on intermediate and basic volcanic rocks on hilly and steep slopes, usually very stony. In the South Island they occur in the drier eastern and central regions. Loess is a common constituent of the parent materials.

In the Solomon Islands they occur in association with Chromic Cambisols on San Cristóbal, and in the Santa Cruz group on basaltic and andesitic volcanics in mountainous terrain. In the New Hebrides they are found on Pleistocene volcanics of the Shepherd islands and on steep slopes of a number of other islands.

Land use. The more extensive areas in Australia remain under natural forests that yield useful hardwood timbers. Smaller areas have been cleared to provide grazing for cattle, and specialty crops, such as tobacco, are grown in favoured areas.

In New Zealand the soils are fertile, and where rainfall is adequate high-producing pastures can be developed. On easier land some cropping is possible, but careful management is necessary to maintain soil structure and control erosion.

In the Solomon Islands they are largely under forests, with small areas used for shifting cultivation for subsistence crops. In the New Hebrides the soils on recent volcanics are used for intensive cropping, those on steep slopes for shifting cultivation.

Bf. FERRALIC CAMBISOLS

Soil characteristics. Ferralic Cambisols in Australia have uniform, medium-textured profiles. The Au1 horizons are dark grey-brown silty clay loams or clay loams, and pass into paler, but not bleached, Au2 horizons which tend to be yellowish or reddish brown. The soil material is noticeably organic and of crumb to subangular blocky structure. It passes gradually into the B horizons which are red-brown or yellow-brown, angular blocky, silty clay loams or clay loams. These soils are usually about 1 m deep, and below this depth pass into increasing amounts of soft weathered parent rock, mainly phyllites and schists, or little altered alluvium derived from them. They are strongly acid soils of low base status and are classed as Um 4.4 on the Factual Key. In the New Hebrides these soils are mainly derived from volcanic ashes on coral limestones. They are high in halloysite clay, exchangeable cations, humus and water.

Distribution. Ferralic Cambisols in Australia occur in the wet (> 1 250 mm) coastal ranges of northeast Queensland. In the New Hebrides they are found on low limestone plateaus on many islands.

Land use. Most areas of these soils in Australia are still under virgin rain forests, but some small areas have been cleared for pasture development and sugarcane production. In the New Hebrides they are used for coconut, cocoa, or coffee plantations, and for high-producing pastures.

Bh. HUMIC CAMBISOLS

Soil characteristics. Humic Cambisols in Australia have uniform medium-textured profiles with dark surface horizons overlying reddish or brownish subsoils. The A horizons are black, very dark brown or very dark reddish brown loams, peaty loams or clay loams of crumb to granular structure. This mineral soil material contains a distinct accumulation of well-humified organic matter and varies from 20 cm to 1 m in thickness. It gradually merges into the colour B horizon, which is red-brown, brown or yellow-brown loam or clay loam. It is very friable and its structure, which may be granular or blocky at the beginning, becomes massive with depth. Texture usually becomes slightly coarser in the yellowish or greyish C horizon. Gravel, stones and boulders occur throughout the profiles of these permeable acid soils. They are the Um 7.11 soils of the Factual Key.

In Papua New Guinea they have deep, dark, fine-textured A horizons, overlying grey-brown to brown but similarly textured B horizons.

Distribution. Humic Cambisols are restricted in Australia to the alpine and subalpine tracts of south-eastern Australia and Tasmania. They occur on rocks weathered *in situ* and on colluvium. The main parent rocks include granites, gneisses, basalts and dolerites.

In Papua New Guinea they are widespread throughout the central mountain chain on metamorphic, sedimentary and igneous rocks.

In New Zealand they are found on the Wairau and Canterbury plains in the east of the South Island. They are formed mainly on greywacke loess and alluvium.

Land use. The larger areas in Australia remain under natural grassland, woodland, forest or heath. They have been used mainly for the summer grazing of sheep and cattle, but this practice is now being restricted in order to conserve the alpine and subalpine tracts as they provide the chief source of water for irrigation and the generation of hydroelectric power.

In Papua New Guinea slopes are generally steep and unstable, and on these the agricultural potential is very low.

In New Zealand they are now highly productive soils, used for intensive sheep farming, dairying and cash cropping.

E. Rendzinas

Soil characteristics. In Papua New Guinea these are shallow dark soils with a loamy to clayey texture, which are always well structured and friable and overlie limestone or limestone detritus. They are young soils occurring generally on steep to very steep slopes or on coral terraces. The soil reaction is mainly neutral to weakly alkaline.

Distribution. Rendzinas in Papua New Guinea cover large areas in the highlands, the Gulf district and New Britain.

Land use. Steep slopes and shallow soils strongly limit the agricultural potential. However, there is some scope for tree crops on the uplifted coral terraces.

F. Ferralsols

Fa. Acric Ferralsols

Soil characteristics. Acric Ferralsols in New Caledonia cover most of the massif of ultrabasic rocks in the south of the island. They are characterized by very dark red colours derived from their main constituents, oxides and hydroxides of iron. Their morphology depends on their position in the landscape: on flat or near flat surfaces they are deep and gravelly and sometimes covered with a continuous or broken iron cuirass; on sloping surfaces they are less gravelly and moderately deep; on steep slopes they are often thin, with rock outcrops. Textures are clay loam or clay, and structures are weakly developed, particularly in the upper horizons.

In the New Hebrides they are rich in amorphous alumina, iron hydroxides and gibbsite, and very poor in bases and phosphorus.

Distribution. These soils occur on ultrabasic rocks which are most extensive in the south of New Caledonia. In the New Hebrides they are derived from volcanic ashes on high plateaus with very wet climates.

Land use. Their extremely low fertility has restricted agricultural use in New Caledonia, but with fertilizing it is proving possible to grow trees, and forestry, with the dual aims of wood production and erosion control, is expanding. In the New Hebrides they are kept under forest.

Fo. Orthic Ferralsols

Soil characteristics. Orthic Ferralsols in New Zealand are strongly weathered and leached soils from basalt, called friable clays or ironstone soils. The A horizons are dark greyish brown friable clays with strongly developed granular structure and many ironstone concretions. The B is brown with the amount of concretionary material increasing to 50 percent. The C horizon, at a depth of about 50 cm, is paler, and rich in gibbsite. The soil is acid and of extremely low base status. It is classified as a very strongly leached brown loam with ironstone nodules.

In the Solomon Islands these soils usually have dark brown to dark reddish brown topsoils, some mollic, over yellowish red or brown silty clay to clay textured subsoils. Depths are generally greater than 100 cm.

Distribution. Orthic Ferralsols occur in gently undulating land in the north of New Zealand. They are formed under forest on deeply weathered basalt sheets in a warm humid climate. In the Solomon Islands they are found mainly over ultrabasic and basic volcanic rocks.

Land use. Considerable areas in New Zealand remain under scrub, but with heavy fertilizer applications it has proved possible to develop pastures. Summer dryness is a problem accentuated by the low water retention capacity of the soil.

In the Solomon Islands they are still mainly under forest, large areas of which are being exploited for timber.

Fp. Plinthic Ferralsols

Soil characteristics. Plinthic Ferralsols in Australia have texture profiles that become increasingly clayey with depth and contain a plinthic horizon which is an irreversibly dried hardpan. The A horizons are usually dark brown to dark red-brown sandy loams or loams that dry to a structureless but porous mass. They grade into B horizons of red, massive oxic material which is highly porous, hard when dry and friable when moist. Textures range from sandy clay loam to clay. The plinthite may occur in the lower portion of the B horizon but is also represented by boulders and gravels scattered on the soil surface and through the profile. It is usually dominantly bauxitic in character. These acid soils are derived from highly sesquioxidic parent materials, laterites and bauxites.

Distribution. The larger areas of the Plinthic Ferralsols occur in the northern part of the Northern Territory, but smaller areas or their remnants are widespread across northern Australia.

Land use. The more extensive areas remain under natural woodlands and support sparse cattle grazing. Mining of the bauxite is being carried out in some localities.

Fr. Rhodic Ferralsols

Soil characteristics. Rhodic Ferralsols in Australia have texture profiles that are either clayey throughout or become increasingly clayey with depth. This latter group is more widespread. The A horizons are very dark brown to dark reddish brown sandy loams, loams, clay loams or light clays with from weak to strong crumb structure, and they usually grade into red-brown E horizons. Each of these horizons ranges from 10 to 20 cm in thickness. E horizons are usually absent in the clay members of the class. The A or E horizons grade into B horizons that consist of red massive oxic material which is highly porous, hard when dry and friable when moist.

Textures range from sandy clay to clay. In the clay members, B horizons may have strong fine polyhedral structure. Profile depth usually ranges from 1 to 2 m and there are some segregations of sesquioxides as nodules and concretions. These acidic soils have low base status and include the Uf 5.21 and Gn 2.14 soils of the Factual Key. In the New Hebrides they do not have E horizons and are very low in bases and available phosphorus.

Distribution. Rhodic Ferralsols occur in humid coastal regions of eastern and northern Australia, and also in the southwest of Western Australia on terrain ranging from plains and undulating lands to steep valley side slopes. They are derived from a range of parent materials with high silica and sesquioxide contents. In the New Hebrides they are formed on old andesitic tuffs or basaltic lavas.

Land use. Some areas remain under natural forest, but much clearing for the establishment of volunteer and improved pastures and specialty crops, mainly sugarcane, pineapples and other horticultural crops, has taken place. In the New Hebrides they support forest.

Fx. Xanthic Ferralsols

Soil characteristics. Xanthic Ferralsols in Australia have texture profiles that are clayey throughout or become increasingly clayey with depth, the latter group being the more common. The A horizons are grey or grey-brown sandy loams, loams, clay loams or light clays with from weak to strong crumb structure that usually grades into yellowish brown E horizons. Each of these horizons ranges from 10 to 20 cm in thickness, but E horizons are usually absent in the clay members of the class. The A or E horizons grade into the B horizons, that consist of yellowish massive oxic material which is highly porous, hard when dry and friable when moist. Textures range from sandy clay to clay. In the clay members, B horizons may have strong fine polyhedral structure. Profile depths usually range from 1 to 2 m. There are some segregations of sesquioxides as nodules and concretions. These acidic soils have low base status and include the Uf 5.23 and Gn 2.24 soils of the Factual Key.

Distribution. Xanthic Ferralsols are commonly associated with Rhodic Ferralsols in the humid coastal regions of eastern and northern Australia, on terrain ranging from plains to hilly and mountainous lands. They are derived from a wide range of parent materials with high silica and sesquioxide contents. In the New Hebrides they are formed from basaltic scoria in Eromanga and alluvial clays in Efate and Espíritu Santo.

Land use. Some areas in Australia remain under natural forest but others have been cleared for grazing. In the New Hebrides they are used for forestry or shifting cultivation, rarely for pastures.

G. Gleysols

Gh. Humic Gleysols

Soil characteristics. Humic Gleysols in Australia have uniform clay-textured profiles that exhibit features of wetness in the subsoil. A surface layer of partially decomposing plant litter may be present or the surface may be bare. The A horizons vary from almost black to very dark grey-brown or grey heavy clay loams or light or peaty clays, that pass into clays or silty clays above a depth of 10 cm. The soil material is crumb to blocky and friable when moist but hard and massive when dry. The A horizons pass gradually into B horizons at depths of about 20 cm. The B horizons are blocky or prismatic clays that vary in colour from yellow-grey to very dark grey or grey-brown, with prominent light grey, reddish, brownish or yellowish mottles. Below depths of 80 to 120 cm the dominant colours become grey with prominent reddish mottlings. These acid soils include the Uf 6.4 soils of the Factual Key.

In New Zealand only one area is large enough to isolate on the map. The soils have the typical gley features noted above but to the south of the area, where the parent materials contain much pumiceous material, textures are sandy.

Distribution. Humic Gleysols are most commonly found on the wet alluvial marine plains along the southeastern, eastern and northern coasts of Australia.

In New Zealand they occur mainly on swampy floodplains in the north of the country.

Land use. These soils usually require draining before they can be used for agriculture. In Australia some areas have been reclaimed for sown pastures and vegetable crops, including potatoes in the south and sugarcane in Queensland.

In New Zealand most areas have been drained and developed for intensive sheep and dairy farming.

H. Phaeozems

Hh. HAPLIC PHAEOZEMS

Soil characteristics. Haplic Phaeozems in Australia have uniform fine-textured profiles that are moderately to strongly structured. The A horizons range from very dark grey to black, and through very dark brown to dark reddish brown light to medium clays of crumb, granular or fine subangular blocky structure at the surface, usually becoming coarser with depth. As a rule the immediate surface is loose when dry, soft and friable when moist, and plastic when wet. The B horizons range from very dark grey or black to red-brown, and are light to medium clays of strongly developed blocky structure. Soil depth varies from 20 cm to about 1 m. They are mildly acid to mildly alkaline soils, usually of moderate fertility, but applications of phosphatic fertilizers are necessary to maintain productivity. They include the Uf 6.1, Uf 6.2 and Uf 6.3 soils of the Factual Key.

In Papua New Guinea a typical profile has a deep, very dark greyish brown A horizon, with weakly developed fine blocky structure; consistence is extremely firm and the texture is heavy clay. The B horizon is a yellowish brown, firm, silty heavy clay, with weak, very fine blocky structure, overlying at 72 cm a light grey-brown fragmented siltstone mixed with some brown clay.

In New Zealand subsoils are commonly yellowish brown and textures silt loam. A fragipan is usually present. They occur in the yellow-grey earth soil group.

Distribution. Haplic Phaeozems in Australia extend from the humid coast to the more arid interior, particularly of the central eastern region, wherever suitable parent materials occur. These include basalts, serpentinite, diorite, some calcareous sediments, and alluvium derived from these sources.

In Papua New Guinea they occur in drier areas on gently undulating fan surfaces. The most extensive areas are in the Markham valley. In the New Hebrides they are found in the leeward areas of the older high islands. They are derived from volcanic ashes on coral limestone.

In New Zealand they occur on rolling loess-covered downlands on the subhumid east coast of the South Island. They are found today only as subdominants and inclusions, but before the soils of the region were heavily cropped in the early days of settlement they must have been far more extensive.

Land use. The largest extensions in Australia are used for the grazing of native pastures by sheep and cattle. Sown pastures have been developed in some areas, and in others some cropping, including cereals, is practised.

In Papua New Guinea these soils have a high potential for arable crops, tree crops and pasture. The relatively dry climate, however, could cause drought stress in some arable crops. In the New Hebrides they are little used.

In New Zealand, also, there is some cropping, but most of the soils are highly developed for intensive sheep farming.

Hl. LUVIC PHAEOZEMS

Soil characteristics. Luvic Phaeozems in Australia have texture profiles that become increasingly clayey with depth. The A horizons are well-developed black, dark brown or dark reddish brown loams, clay loams or light clays with strong crumb, granular or fine subangular blocky structure. These A horizons grade into E or B horizons. The E horizons are not as dark as the A, and are more coarsely structured. They grade into the B horizons. The argillic B horizons range from black to brown or reddish brown medium or heavy clays of strong blocky structure. These soils are very friable when moist and at depths of 0.3 to 1.5 m pass into C horizons with weathered rock. They have mildly acidic surface soils and include the Gn 3.22, Gn 3.24, Gn 3.42, Gn 3.43 and Gn 4.4 soils of the Factual Key.

Distribution. Luvic Phaeozems occur in the humid regions of eastern Australia wherever there are suitable parent materials. These include basalts, other basic igneous rocks, some shales and siltstones, and alluvium derived from these sources.

Land use. The more extensive areas are used for sheep and cattle grazing of native, volunteer and improved pastures. There is also some cropping and specialty crop production.

I. Lithosols

Soil characteristics. These soils are less than 10 cm in depth to hard rock. They have uniform coarse- or medium-textured profiles, mainly with rudimentary A horizons. Colours range from red-brown through brown to grey, and apart from a slightly darkened surface there is no change through the profile.

In the Solomon Islands the soils are humic and overlie limestone.

Distribution. Lithosols occupy undulating, hilly and mountainous uplands throughout Australia. They are characterized by shallow depth and frequent rock outcrops. Many rock types are included, such as granites, gneisses, schists, phyllites, sandstones and quartzites. In Papua New Guinea they are widespread, occurring in the alpine zones and hilly areas having a pronounced seasonal climate. In New Zealand they are found mainly with Podzols and Cambisols in the alpine zone and on the steep flanks of the Southern alps.

In the Solomon Islands Lithosols are widespread in associations with Orthic Ferralsols and Chromic Cambisols on raised coral platforms. They are found on all slopes.

Land use. In Australia most areas are used for the sparse grazing of the natural vegetation by sheep and cattle. In Papua New Guinea, because of limitations of climate and landform, Lithosols have no agricultural potential.

In New Zealand and the Solomon Islands, also, these soils are not used for agriculture.

J. Fluvisols

Je. EUTRIC FLUVISOLS

Soil characteristics. Eutric Fluvisols are young soils on recent alluvium, so profiles are not strongly developed. Commonly, however, a distinct ochric A horizon is present and lower horizons show evidence of gleying. B horizon colours are usually pale and lack the colour differentiation from the underlying horizon that would be evidence of mineral weathering. Structures are weakly developed.

Distribution. These soils are widely distributed along floodplains of rivers and streams, but the units are usually too small in area to show on the scale of the map. In Papua New Guinea, however, they are dominant in relatively large areas of alluvial plains.

Land use. Being flat and fertile these soils are often of high agricultural value, but drainage is usually required before they can reach their full potential. In Papua New Guinea they are suitable for arable and tree crops. In many areas forest resources could be exploited. Where drainage is poor and flooding occurs crops cannot be grown, except for some paddy. Sago is the main source of food in these areas.

K. Kastanozems

Kh. HAPLIC KASTANOZEMS

Soil characteristics. Haplic Kastanozems in Australia have uniform medium-textured profiles that are moderately to strongly stuctured and have a brownish tinge even when moist. The A horizons are distinctly organic and range from very dark brown to dark reddish brown and dark grey-brown silty or fine sandy loams or clay loams. They have crumb, granular or fine blocky structure and their consistence is friable both dry and moist. They are 10 to 20 cm thick and grade into the B horizons. These range in colour from very dark brown to red-brown and grey-brown and are prismatic, blocky or polyhedral. Some calcium carbonate as both hard and soft segregations may occur. Soil depth usually varies from 0.6 to 1.5 m, but may be as shallow as 0.2 m. The Um 6.1, Um 6.2 and Um 6.3 soils of the Factual Key are included.

Distribution. Haplic Kastanozems occur widely, but in small extensions, throughout the humid to semiarid areas of Australia, particularly in the southeast and the southwest. They are developed largely on base-rich rocks, such as basalts, or on alluvium and colluvium derived from them.

Land use. The more extensive areas are usually under improved pasture for sheep and cattle grazing. Smaller areas are used for specialty crops such as potatoes, maize, onions and sugarcane.

Kk. CALCIC KASTANOZEMS

Soil characteristics. Calcic Kastanozems in Australia have texture profiles that become increasingly clayey with depth and are calcareous throughout. The A horizons are dark greyish brown sandy loams or loams that are distinctly organic and calcareous. They pass gradually into the B horizons at depths of about 20-30 cm. The B horizons range from grey-brown to dull brown calcareous sandy clay loams or sandy clays, and contain a calcic layer. Soil depth is usually about 1 m and the C horizons are stratified calcareous sediments. The Gc 1.11 soils of the Factual Key probably belong here.

Distribution. These soils occur on plains in the semihumid areas of southern South Australia.

Land use. These soils are used for wheat production and improved pastures for sheep and cattle grazing.

L. Luvisols

La. ALBIC LUVISOLS

Soil characteristics. Albic Luvisols in Australia have coarse- to medium-textured surface soils overlying clay subsoils. The A horizons are moderately organic dark grey-brown loams, 15 cm or more in thickness, with moderate crumb structure. There is a clear boundary to fairly thick light grey-brown E horizons that are bleached with depth and weakly blocky to massive. The boundary to the B horizon is clear but irregular. The B horizon is a red-brown clay with moderate to strong blocky structure. It then grades through mottled medium to heavy clays into a weathered rock C horizon at depths of 1 to 2 m. These acid soils are classed as Dr 4.41 on the Factual Key.

Distribution. Albic Luvisols occur mainly in the humid subtropics, associated largely with colluvium derived from metasediments, granites and andesites.

Land use. Most areas support little-altered native vegetation, and are used for forestry and some cattle grazing.

Lc. CHROMIC LUVISOLS

Soil characteristics. Chromic Luvisols in Australia cover a wide range of soils having brown to red argillic B horizons. Some have texture profiles that gradually increase in clay content with depth, but most have distinct texture contrast profiles with coarse or medium surface soils overlying clay subsoils. A few A horizons are soft and friable, but the majority are hardsetting. Some subsoils are massive, but most are moderate to strong blocky or prismatic. Soil depth generally ranges from 0.5 to 1 m. They are usually acid soils. Included are the Gn 2.15, Dr 2.11, Dr 2.12, Dr 2.21, Dr 2.22, Dr 2.61, Dr 3.22, Dr 4.12, Dr 4.21, Db 1.22 and Db 3.12 soils of the Factual Key.

In the Papua New Guinea islands profiles would fall into the range described above. The A horizons are mainly dark brown, hard when dry, with weak to moderately developed structures. The B horizons are dark reddish brown to dark red, friable, with weak structures. Clay contents are very high.

Distribution. Chromic Luvisols are widespread throughout Tasmania and the hinterlands of Australia, mainly on plains and hillslopes. They are formed from a wide range of parent rocks, including granites, granodiorites, gneisses, sandstones, dolerites and basalts, and colluvium and alluvium derived from these.

In Papua New Guinea they are found in association with Rendzinas and other soils on limestone in the highlands, and on coral sand throughout the islands.

Land use. In Australia the use of these soils ranges from grazing of native and improved sown pastures to cereal cropping, horticulture, specialty crops and forestry.

In Papua New Guinea their use in the highlands is restricted by the steep slopes and difficult terrain, and they have little potential for agricultural development. In the islands they occur on level surfaces and have a high potential, particularly for tree crops such as coconut. Arable cropping and grazing would also be possible.

Lf. FERRIC LUVISOLS

Soil characteristics. Ferric Luvisols in Australia have texture contrast profiles, with an argillic B horizon showing many coarse reddish and brownish mottles. The A horizons range from dark grey to dark yellowish brown and from sands to clay loams. Some are soft and friable but most are hardsetting. There is a gradual change to a paler, but not bleached, E horizon. The thickness of the A and E horizons varies from 10 to 50 cm, and there is a clear to abrupt boundary with the B horizon. Ironstone gravels are commonly present in the A and E horizons. The B horizons are yellowish or brownish clays with reddish, strong brown and grey mottlings. These clays are massive and kaolinitic, and very thick. They become even more prominently mottled in red and grey with depth. Soils are 1 to 2 m thick. These acid soils are classed as Dy 3.61 and Dy 5.61 on the Factual Key.

Distribution. These soils are most common in southern Australia and Tasmania, on gently sloping, undulating or hilly lands resulting from the dissection of lateritic plateaus.

Land use. Many areas have been developed to sown clover pastures by using phosphatic fertilizers with trace elements after clearing the natural woodland or forest. Other areas remain under their natural vegetation and some are used for forestry.

Lg. GLEYIC LUVISOLS

Soil characteristics. Gleyic Luvisols in New Zealand have an argillic horizon sufficiently well developed to restrict drainage and allow gleying in and above the B horizons. Topsoils are dark silt loams, friable and moderately well structured. Subsoils are typically pale heavy silt loams or clay loams, firm, with weak blocky structures. Many overlie a massive or coarsely structured fragipan. They are classified as clay illuvial yellow-grey earths.

Distribution. They are found on downlands in southern areas of the North Island and eastern areas of the South Island of New Zealand where leaching has been insufficient to form the more common Gleyic Acrisols. They are formed on loess or, in places where loess is thin, on underlying sedimentary rocks.

Land use. These soils have been used for cropping, but they are liable to erosion and are now mainly under pasture for sheep production.

Lk. CALCIC LUVISOLS

Soil characteristics. Calcic Luvisols in Australia have texture contrast profiles, with an argillic B horizon and segregations of carbonates in the deeper subsoil. The A horizons range from dark grey-brown to dark brown and dark reddish brown loamy sands to clay loams, with sandy loam and loam textures being most common. The E horizons, clearly paler in colour than the A, are not bleached. The thickness of the hardsetting A and E horizons ranges from 8 to 50 cm. There is usually a clear boundary with the underlying B horizon, which is a strongly structured red-brown or red, blocky, polyhedral or prismatic clay. Ped faces are smooth and shiny. With depth colour becomes less red and segregations of soft and nodular carbonates appear at depths of 30 to 90 cm. Soluble salt contents and exchangeable sodium levels are low to very low. These soils are classed as Dr 2.23 on the Factual Key.

Calcic Luvisols, sodic phase, occur with Orthic Solonetz, which have a calcic horizon. In the Calcic Luvisols, sodic phase, the exchangeable sodium varies from 6 to 14 percent of the exchangeable cations, while in the Solonetz it is 15 percent or more. Profiles are very similar to those of Calcic Luvisols, but either have no E horizon or nests of bleached material at the AB interface.

Colours in the blocky or prismatic B horizon clays range from red-brown to brown and yellow, depending on differences in subsoil permeability. Soils classed as Dr 2.13, Dr 2.33, Db 1.13, Db 1.33, Dy 2.33 and Dy 3.33 by the Factual Key are included.

In New Zealand subsoils tend to be yellowish brown or brown rather than red, and stones are common. They are classified as brown-grey earths.

Distribution. Calcic Luvisols are widely distributed through eastern and southern Australia, and to a lesser extent western Australia, in the subcoastal hilly land and undulating margin of the inland plains. Their largest areas of occurrence are in southeastern Australia.

Parent materials include slates, calcareous shales and calcareous alluvium.

Calcic Luvisols, sodic phase, occur extensively on the inland plains of eastern, southern, western and southwestern Australia. They are developed on calcareous alluvium and colluvium.

In New Zealand, Calcic Luvisols are formed on loess, alluvium and solifluction debris in the semi-arid intermontane basins of the South Island.

Land use. Most of these Calcic Luvisols are arable, and are extensively used for wheat growing and associated sheep and cattle raising on volunteer and sown pastures. In areas of higher rainfall, or where irrigation water is available, horticulture, viticulture and vegetable production are favoured.

In New Zealand they are mainly under improved pastures for sheep production, using dryland farming techniques. Where irrigation water is available, intensive fruit growing or pasture production is practised.

Lo. ORTHIC LUVISOLS

Soil characteristics. Orthic Luvisols in Australia have texture contrast profiles with an argillic B horizon. The A horizons range from dark grey to dark grey-brown loamy sands, sandy loams or loams, and there is usually a paler E horizon. These hardsetting A and E horizons range from 10 to 60 cm in thickness. There is a clear to abrupt boundary to the clay B horizons, which are commonly yellowish but may be mottled with greys, reds and browns. Structures are polyhedral, blocky or weakly prismatic. With depth there is a gradual change to underlying sediments or weathered parent rock at depths of 0.6 to 1 m. These mildly acidic soils belong to the Dy 2.21, Dy 2.22, Dy 3.21 and Dy 3.22 classes of the Factual Key.

Orthic Luvisols, sodic phase, occur with, and are similar to, Orthic Solonetz soils. They have exchangeable sodium levels varying from 6 to 14 percent of the exchangeable cations, while in Solonetz soils they are 15 percent or more. These acidic soils are classed as Dy 3.31 and Dy 3.32 by the Factual Key.

In New Zealand, Orthic Luvisols are found in the clay-illuvial yellow-grey earths.

Distribution. Orthic Luvisols have developed on a wide range of sedimentary rocks, clayey alluvium and some granodiorites, on hillslopes and plains in the seasonally humid zones of eastern, southern and southwestern Australia.

Orthic Luvisols, sodic phase, occur in the seasonally humid regions of eastern and northern Australia, particularly in Queensland, on a wide variety of parent materials, from sedimentary and metamorphic rocks to clayey alluvium and colluvium.

In New Zealand they are formed on loess and sedimentary rocks on downlands and hills in the east of both islands.

Land use. The principal use of these soils has been for the grazing of sheep and cattle on natural, volunteer and sown pastures. Limited areas are utilized for dryland horticulture and viticulture.

Soils of the sodic phase are of low fertility, and usually allow only the sparse cattle grazing of native pastures.

In New Zealand they are ured for sheep farming, mainly on improved pastures.

N. Nitosols

Nd. DYSTRIC NITOSOLS

Soil characteristics. Dystric Nitosols have texture profiles that become increasingly clayey with depth, and an argillic B horizon. The A horizons range from black to dark brown and reddish brown loams, clay loams or light clays. They are strongly structured and friable. These A horizons grade texturally into the B, and there are no colour E horizons except in the Gn 3.14 soils. The B horizons are strongly structured, red, red-brown or brown clays that are very friable. Their peds are either smooth-faced and shiny (Gn 3.1), or rough-faced and porous (Gn 4.1). They are deep soils with thick B horizons in which weathered parent materials may be as deep as 6 or 7 m.

Parent materials are granites, other acid igneous rocks, shales and mudstones for Gn 3.14 soils, and basalts for the Gn 3.10, Gn 3.11, Gn 4.11 and Gn 4.31 soils of the Factual Key.

Distribution. Dystric Nitosols occur extensively in the high rainfall areas of eastern and southeastern Australia and northwestern Tasmania, wherever suitable parent materials are present.

In the Solomons they occur extensively with Acrisols and Luvisols on Russell Island. They are formed on raised coral platforms from Pleistocene coral limestone and volcanics.

Land use. These soils have been widely developed in Australia to provide pastures for dairy farming, and to grow specialty crops, including groundnuts, sugarcane, maize, potatoes, strawberries and floricultural crops. Some areas still under forest provide valuable timber.

In the Solomon Islands they are used for coconut plantations and for subsistence farming for food crops.

Ne. EUTRIC NITOSOLS

Soil characteristics. In Australia Eutric Nitosols have texture profiles that become increasingly clayey with depth, and an argillic B horizon. The A horizons range from dark brown to reddish brown loams or clay loams. They are friable and strongly structured but generally have coarser peds than those found in Dystric Nitosols. The A horizons grade texturally into the friable red clay B horizons, in which polyhedral or blocky peds predominate. Clay subsoils are fairly thick but grade into weathered parent materials at depths of about 1 to 3 m. Eutric Nitosols, classed as Gn 3.12 on the Factual Key, have near-neutral pH values whereas the Dystric Nitosols are acid.

Distribution. Eutric Nitosols are formed *in situ* on basalts and other basic igneous rocks under a lower rainfall than Dystric Nitosols. They extend across northern Australia, and also occur throughout eastern Australia.

Land use. These soils are used mainly for cattle grazing of native pastures in northern Australia. But in Victoria and New South Wales they are cropped to wheat, and sown pastures have been established for sheep and cattle grazing.

O. Histosols

Od. DYSTRIC HISTOSOLS

Soil characteristics. Dystric Histosols in Australia, under natural conditions, are usually maintained near saturation for long periods by rainfall or a water table at shallow depth. Their main feature is a surface layer, varying in thickness from 30 cm to more than 1 m, of black to brown peat, loamy to clayey peat, or peaty loam to sand. This usually contains some recognizable plant remains in the upper part. At depth this layer grades into mineral material — sandy, loamy or gravelly — or below the level of the water table it may merge into brown peaty material. In these acid soils pH is generally between 4 and 5. They are classed as 0 acid on the Factual Key.

In New Zealand they are also usually found on low-lying flat areas with a high water table, but in the far south, on Stewart Island and on the subantarctic islands they occur as well on sloping land as " zonal peats." In these wet, cold, acid conditions the rate of organic matter decomposition is less than its rate of formation.

Distribution. Dystric Histosols are fairly widespread in southeastern, eastern and southwestern Australia and in Tasmania, even though individual areas are relatively small. Most occur in the high mountains and plateaus above the winter snow line, but others are found in wet depressions in coastal and subcoastal plains.

Distribution in Papua New Guinea and New Zealand is similar. Mapping units with Histosols dominant, however, occur only in the New Zealand area, in Southland, Chatham Island, and the subantarctic.

Land use. Dystric Histosols are not used except where incidental to the use of associated soils they provide sparse summer grazing for sheep and cattle. A few areas have been drained and developed for dairying on sown pastures and for intensive vegetable farming.

Oe. EUTRIC HISTOSOLS

Soil characteristics. Eutric Histosols have characteristics similar to the Dystric Histosols except for their higher pH values throughout the soil. In Papua New Guinea they are very common on tidal mangrove flats.

Distribution. Eutric Histosols are common in estuaries and along flat coastal areas of the Papua New Guinea mainland.

Land use. These soils are unsuitable for agriculture. Some areas have large timber (mangrove) resources.

P. Podzols

Ph. HUMIC PODZOLS

Soil characteristics. Humic Podzols in Australia have uniform coarse-textured profiles, with bleached E horizons and compacted or cemented spodic B horizons. The A horizons range from brownish grey to black, and are commonly sands or loamy sands. The surface is generally loose and a mixture of sand and discrete organic particles which give a highly speckled appearance. There is a diffuse boundary to the near-white, bleached E horizon which, when dry, is a loose sand. The thickness of the A and E horizons ranges from 0.3 to over 1 m. There is an abrupt or clear boundary with the B horizons which varies from even to highly irregular. The B horizons are sands to sandy loams strongly compacted or cemented, forming pans that are hard when dry. Cementation is associated with accumulations of organic matter and the most common pan is black to dark brown. Pans vary in thickness from under 2.5 cm to over 1 m, and with depth grade into yellowish sand to sandy clay loam parent material, or abruptly overlie slowly permeable horizons of clay, laterite or rock. Solum depth ranges from less than 1 m to about 10 m. These soils are classed as Uc 2.3 on the Factual Key.

Distribution. Humic Podzols have formed on highly siliceous parent materials in coastal and subcoastal areas of eastern and southern Australia where there is a good moisture supply from rainfall or runon water.

Land use. These soils require shallow surface drainage and adequate fertilizing to develop them for pasture, forestry and arable farming.

Po. ORTHIC PODZOLS

Soil characteristics. Orthic Podzols in Australia have uniform coarse-textured profiles, with bleached E horizons and spodic B horizons. The A horizons range from brownish grey to black and are generally sand or loamy sand. They are frequently a mixture of sand grains and discrete organic particles, resulting in a strongly speckled appearance. This loose surface is 10 to 80 cm thick and has diffuse to clear boundaries with the bleached E horizons. The near-white loose sand subsurface varies in thickness from 10 cm to 1 to 2 m, and has an irregular diffuse to clear boundary with the subsoil. The B horizons may be uniformly coloured or mottled sands or clayey sands with a wide colour range that varies from black to brownish or reddish. They are 30 cm to 1 m thick, and with depth grade into pale-coloured sands or weathered rock, or abruptly overlie clayey horizons. These acid sands are classed as Uc 2.2 on the Factual Key.

In New Zealand Orthic Podzols usually have a deep, acid O horizon, a thin A, a bleached eluvial E, and a well-defined spodic B. Textures may be as fine as silt loam.

Distribution. Orthic Podzols have developed on highly siliceous parent materials, and are widely distributed throughout coastal and subcoastal Australia and Tasmania.

In New Zealand they occur on coastal sands in the north, and with Lithosols and Cambisols in the South Island mountains.

Land use. These soils have largely remained undeveloped because of their low nutrient status and a widely varying moisture regime which ranges from drought to seasonal waterlogging. Cropping, improved pastures and forestry plantations (*Pinus* spp.) have been undertaken in some areas, and their success is dependent on heavy fertilizing.

Pp. PLACIC PODZOLS

Soil characteristics. Placic Podzols in New Zealand have coarse-textured profiles of variable depth, commonly with a dark peaty litter and A horizon, a pale, often humus-stained E, and a spodic B containing a thin hard reddish brown to yellowish red iron pan. They are classified in the podzolized yellow-brown earths and podzols group.

Distribution. These soils are dominant only on Stewart Island in the far south of New Zealand. They are formed on granite and diorite in mountain terrain under heavy podocarp-mixed hardwood forest. Other soils in the association include Rankers, Dystric Histosols, Dystric Cambisols and Lithosols.

Land use. These soils are not used and have little potential for agriculture.

Q. Arenosols

Qa. ALBIC ARENOSOLS

Soil characteristics. Albic Arenosols have uniform coarse-textured profiles, consisting largely of whitish sandy material. The A horizons vary from brownish grey to dark grey sands or loamy sands, which may be strongly speckled with white sand grains. They are loose when dry and are difficult to wet. There is a clear to gradual colour change to the near-white subsurface of sand to clayey sand, which is either loose or massive and compact. Hard materials ranging from siliceous rocks to laterites occur abruptly but irregularly below the bleached soil. Some profiles contain large amounts of ironstone gravel. Soil depth ranges from less than 60 cm to 90 cm.

These soils are classed as Uc 2.12 on the Factual Key. Some soils with loam textures, classed as Um 2.12 on the Factual Key, have been included here because of their general similarity and predominance of albic material.

Distribution. Albic Arenosols occupy flat to undulating sandy areas in the Northern Territory and Western Australia, while in Queensland they occur mainly on hilly to mountainous subcoastal terrain.

Land use. Most areas remain under hardwood forest (*Eucalyptus* spp.) or are used for cattle grazing of native herbage.

Qc. CAMBIC ARENOSOLS

Soil characteristics. Cambic Arenosols in Australia have uniform coarse-textured profiles with colour B horizons. The A horizons range from dark grey to dark red-brown, but are commonly dark grey-brown sands to sandy loams that are loose to massive. Colour lightens with depth and there is a diffuse or gradual boundary to the E horizon. These paler E horizons are not bleached and pass gradually to the B horizons. The B horizons are yellow, brown or red sands to light sandy clay loams. They are weakly coherent, massive and porous. Colour decreases with depth and there is a gradual change to weathered parent material. Soil depth ranges from less than 1 to 2 m. Ironstone gravels occur through those profiles which are developed on detrital lateritic materials. These soils are classed as Uc 4.21 and Uc 4.22 on the Factual Key.

Distribution. Cambic Arenosols are widely distributed from the moist coastal plains through the subcoastal hilly lands to the dry inland plateaus. The parent materials are always highly siliceous and most commonly are aeolian sands, sandstones, granites, quartzites, laterites and sandy alluvium.

Land use. The main development of these soils has been for both hardwood (*Eucalyptus* spp.) and softwood (*Pinus* spp.) production, and also for pastures, but most of the shallow gravelly members remain undeveloped.

Qf. FERRALIC ARENOSOLS

Soil characteristics. Ferralic Arenosols in Australia have uniform, coarse-textured profiles, with coarse-textured " oxic " B horizons. The A horizons range from pale yellowish or reddish browns to dark brown coherent sands to sandy loams. There is a diffuse colour change to the B horizon at depths between 10 and 60 cm. The B horizons range from coherent sand to sandy loam of red, yellow or brown massive, porous and compact material. The coherence and earthy appearance of these subsoils are due to clayey and oxidic coatings and bindings on and between sand grains. With depth there is a gradual change to paler coloured sands or weathered rock, or an abrupt change to hardpans, massive laterite or clay horizons. Soil depth varies from 0.25 to 2 m. Large quantities of ironstone gravels occur through the profile of these soils where they have formed in detrital materials from laterite. They are classed as Uc 5.2 on the Factual Key.

Distribution. Ferralic Arenosols occupy large areas of the arid interior of Australia, with only minor occurrences in coastal areas. The chief parent materials are colluvial sands, but substantial areas of shallow gravelly profiles are found on siliceous hard rocks and on truncated massive laterite.

Land use. Large extensions of the soils in the desert areas have only poor spinifex cover and are not used at all. Elsewhere their native herbage provides sparse grazing for sheep and cattle. Under higher rainfall, some areas in the southwest of Western Australia have been developed for cereal crops and improved pastures following heavy fertilizer application.

R. Regosols

Rc. CALCARIC REGOSOLS

Soil characteristics. Calcaric Regosols in Australia have uniform coarse-textured profiles that are calcareous. Surface soils usually range from dark grey through grey-brown to brown sand to sandy loam that is typically loose and structureless. They are often calcareous, and at a depth of 30 cm or less pass into calcareous sands consisting largely of shell fragments with carbonate contents varying from 10 to over 80 percent.

Colour varies from yellowish to brownish and reddish. The calcareous material often exceeds 3 m in thickness, but may be as thin as 30-40 cm where it covers other soil or rock formations. They are classed as Uc 1.1 on the Factual Key.

Distribution. These soils are found on recent calcareous dunes and sand sheets formed along the coastline behind the modern beach zone. They also occur on young coral reefs in many of the low altitude islands.

Land use. Many areas remain unused, but the grasslands of the Bass Strait islands and the southern Australian mainland coast have been used for sheep and cattle grazing for a long time. More recent development on Yorke peninsula, South Australia, includes medic pastures and cereal cropping, especially barley. The trace elements cobalt, copper and manganese are often essential. Wind erosion can be a serious hazard.

Rd. DYSTRIC REGOSOLS

Soil characteristics. Dystric Regosols in Australia have uniform coarse-textured profiles that are siliceous. Surface soils range from brownish grey through grey-brown to red-brown sands that are mostly loose and structureless. These slightly darkened surface soils gradually pass into subsurface sands, loamy sands or clayey sands, that vary from pale yellow or pale grey to brown and red in the different soils. The thickness of this sandy quartzose material varies greatly, from less than 60 cm to over 6 m. These soils are classed as Uc 1.2 on the Factual Key.

In New Zealand they occur on coastal sands, and are classed as yellow-brown sands. In New Caledonia they are found in steep terrain on acid rocks.

Distribution. These soils have a wide distribution in Australia and occur on four main landforms: recent coastal dune formations, recent dunes and sand sheets adjacent to functional and nonfunctional drainage lines, dunes and swales of sand deserts, and hilly areas on colluviated slopes derived from siliceous rocks. The last usually have shallow forms of this group.

In New Zealand they are mapped on recent coastal dunes in the north of the North Island. In New Caledonia they are found in relatively small areas through the mountain chain, but they also occur on the coasts and are extensive on the schist and schist-gneiss massif of the northeast coast, which rises from the sea to over 1 600 m at the summit of Mount Panie.

Land use. The most widespread use of these soils in Australia is for the sparse grazing of sheep and cattle, but in favoured areas specialty crops, such as citrus, are grown under irrigation, for example in the Riverine plain of New South Wales.

In New Zealand they are used for sheep farming, often providing useful winter grazing. Exotic forestry (*Pinus* spp.) is an important development in some areas. In New Caledonia they are not utilized.

Re. EUTRIC REGOSOLS

Soil characteristics. Eutric Regosols in Australia have uniform coarse-textured profiles. They are grey-brown, brown or red-brown loamy sands or sandy loams that are slightly darker in the immediate surface soil. Below the soil, at depths varying from 10 to 60 cm, are rock or hard carbonate pans. These mildly acid to neutral soils are classed as Uc 6.11 and Uc 6.13 on the Factual Key.

In New Zealand they are found on recent coastal sands or recent deposits of volcanic ash. They are coarse textured with uniform profiles. In the New Hebrides they are found on very recent volcanic ash or on steep slopes.

Distribution. They occur mainly around the southern Australian coast on dunes, plains and hills of consolidated calcareous dune sand and dune limestone, and in subcoastal areas on intermediate rocks.

In New Zealand they are mapped on the southwest coast of the North Island and around volcanic centres in the central North Island.

Land use. Small areas are cultivated for cereals, mainly barley, while others have been developed for improved pasture, but these soils are mainly used for the sparse grazing of natural and volunteer herbage.

In New Zealand they are used for pastoral farming or exotic forestry (*Pinus* spp.). In the New Hebrides they are generally under forest.

S. Solonetz

So. ORTHIC SOLONETZ

Soil characteristics. Orthic Solonetz are texture contrast soils in which the exchangeable cations of the clay B horizon contain more than 15 percent sodium. The A horizons are commonly grey-brown and range from loose sand to hardsetting loams and clay loams. They pass into near-white bleached E horizons at depths of 10-12 cm, which in turn pass abruptly into blocky or prismatic clay B horizons at depths of 20-60 cm. The B horizons are variously mottled. These soils are classed Dy 3.43 and Dy 5.43 on the Factual Key.

Orthic Solonetz are commonly associated with other soils of very similar morphology but with levels of exchangeable sodium below 15 percent. These include sodic phases of Calcic and Orthic Luvisols, Calcic and Solodic Planosols, saline phases of Orthic Solonetz, and Solonetz with calcic horizons.

Orthic Solonetz with calcic horizons have A horizons which are usually grey, grey-brown or brown hardsetting sandy loams, loams or clay loams. These vary in thickness from 5 to 20 cm and often have bleaching at the interface with the sharply separated subsoil. The B horizons range from very dark grey to very dark brown clays of strong blocky or prismatic structure. These are usually 30 to 50 cm thick and grade into massive lighter coloured clays at the beginning of which segretations of carbonates occur. These soils are classed as Dd 1.13, Dd 1.33 and Dd 2.33 on the Factual Key.

The saline phases of Orthic Solonetz have a brittle, platy surface crust, over which a stony pavement often occurs. The soil below is brown, reddish brown or yellowish red loamy sand, sandy loam or clay loam. It varies in thickness from 1 to 20 cm and there is a clear or abrupt change to the clay subsoil, often with some bleaching at the interface. The B horizons are red-brown or red strongly structured clays. Structure weakens with depth and segregations of gypsum and sometimes carbonates occur. Subsoils are highly saline with sodium chloride contents exceeding 0.3 percent at about 15 cm depth and increasing to more than 1 percent below. The profile may be underlain by very stony or gravelly material, sedimentary layers or hard rock, at depths varying from 0.5 to 2 m. These soils are classed as Dr 1.1, Dr 1.3 and Dr 1.4 on the Factual Key.

Distribution. Orthic Solonetz in association with Calcic and Orthic Luvisols, sodic phase, occur in the seasonally humid regions of eastern and northern Australia, particularly in Queensland, on a wide variety of parent materials, from sedimentary and metamorphic rocks to clayey alluvium and colluvium.

Associations with Calcic and Solodic Planosols are extensive on alluvial and colluvial deposits throughout the hinterlands of northern, eastern, southern and southwestern Australia.

Orthic Solonetz with a calcic horizon occur on the alluvial floodplains of many inland streams in eastern and southeastern Australia, where they form part of the complex toposequence of soils developed on alluvium. In association with Calcic Luvisols, sodic phase, they are also widely distributed through eastern, southern, western and southwestern Australia on the inland plains. They are developed on calcareous alluvium and colluvium. Saline phases are typical of the southeastern region of the Australian arid zone with less than 250 mm annual rainfall. They occupy wide plains and associated stony uplands. Their parent materials include weathered clayey sandstones, local alluvium, and possibly aeolian clays.

Land use. Because of low fertility most Orthic Solonetz and saline phases are used only for sparse grazing of native pasture. Where calcic horizons occur the use extends to cereal production and irrigated pastures and crops. Associations with Calcic and Solodic Planosols may also be suitable for forestry and horticulture.

T. Andosols

Th. HUMIC ANDOSOLS

Soil characteristics. Humic Andosols in New Zealand are derived from fine-textured andesitic volcanic ash of Holocene or late Pleistocene age. Topsoils are black to very dark brown loams, friable, with fine subangular blocky structures. Subsoils are yellowish brown to dark greyish brown silt loams, very friable and weakly structured. The soils have low bulk densities, are nonsticky, absorb large amounts of water and have high phosphate retention capacities. The clay mineral allophane is dominant. The soils are classed as yellow-brown loams. In the New Hebrides they also contain gibbsite.

Distribution. These soils are dominant in New Zealand in the area around Mount Egmont in the west of the North Island. They also occur in association with Ochric Andosols further north. In the New Hebrides they are found on the Banks islands, and on the high plateaus of Espíritu Santo, Maewo and Pentecost islands under rainfalls exceeding 4 000 mm annually.

Land use. Humic Andosols in New Zealand have been developed with large applications of phosphate and potassium fertilizers into high-producing grass-clover pastures for dairy and sheep farming. In the New Hebrides they are very poor and are not used.

Tm. MOLLIC ANDOSOLS

Soil characteristics. Mollic Andosols in Papua New Guinea occur on Recent, mainly andesitic volcanic ash. These soils are characterized by a well-developed dark A horizon, merging into a yellow-brown to dark brown B horizon and a thick, coarser textured C horizon. They are usually medium and coarse textured. Subsoils may be partly or wholly compacted and somewhat cemented. The soil reaction varies between 5.5 and 7.5. Buried A horizons are fairly common. Allophane is the dominant clay mineral. In the New Hebrides they are derived from andesitic ash (Tana) or basaltic scoria (Oba). They are dark coloured and friable with granular structures. They have low bulk densities, are nonsticky and have high levels of exchangeable cations and available phosphorus.

Distribution. These soils are common in the eastern part of the Papua New Guinea mainland and the islands of Bougainville and New Britain. In the New Hebrides they are dominant on recent volcanoes, such as those on Tana and Oba islands.

Land use. When not too steep and dissected these soils in Papua New Guinea are suitable for tree crops, pastures and arable crops. They are being used for much of the development of cocoa and oil palm production. In the New Hebrides they are used for the intensive cultivation of coconuts, cocoa and coffee.

To. OCHRIC ANDOSOLS

Soil characteristics. Ochric Andosols in New Zealand are free-draining friable soils derived from fine-textured volcanic ash of Holocene or late Pleistocene age. Topsoils are black to brown, are very friable, and have soft granular to crumb structures. Subsoils are brown to yellow, very friable, with weakly developed subangular blocky structures. The soils have low bulk densities, are nonsticky, absorb large amounts of water and have high phosphate retention capacities. The clay mineral allophane is dominant. The soils are classed as yellow-brown loams.

Distribution. These soils are found on rhyolitic or andesitic volcanic ash between the central North Island region and Auckland. The terrain is mainly rolling or hilly.

Land use. In New Zealand Ochric Andosols have been developed with heavy applications of phosphate and potassium fertilizers into high-producing grass-clover pastures for dairy and sheep farming. Cropping is also practised, and some areas are under exotic forestry (*Pinus* spp.).

Tv. VITRIC ANDOSOLS

Soil characteristics. Vitric Andosols in New Zealand are formed on rhyolitic materials from huge paroxysmal eruptions, the chief of these being the Taupo, about the year 131 AD, and the Kaharoa, about 1300 AD. Topsoils in most places are very dark coloured and subsoils yellowish brown. Textures are sandy to gravelly, consistences friable to loose, and structures weakly developed granular or crumb, or single grain. Bulk densities are low.

Weathering is weak but has produced small amounts of allophanic clay which give the soil medium phosphate retention capacity. The soils are classed as yellow-brown pumice soils. In the New Hebrides Vitric Andosols are derived from very recent fine basaltic ash. They are sandy, low in humus, friable, and weakly structured. They have low water retention and low cation exchange capacity.

Distribution. The Vitric Andosols occupy most of the central volcanic region of the North Island of New Zealand. The terrain is predominantly rolling to hilly in the west and central areas, and steep to mountainous in the east. In the New Hebrides they are dominant around active volcanoes such as those on the islands of Ambrim and Tana.

Land use. The main land uses in New Zealand are exotic forestry, principally *Pinus radiata*, and sheep and cattle farming on grass-clover pastures. Fertilizer requirements for pasture are complex, and phosphorus, potassium, sulphur, magnesium and molybdenum may all be required. Cobalt, selenium, copper and sodium may be needed for animal health. In both forestry and farming high levels of production can be achieved. In the New Hebrides the poorer members are used for shifting cultivation, while the better members are under coconuts and cocoa.

V. Vertisols

Vc. CHROMIC VERTISOLS

Soil characteristics. Chromic Vertisols in Australia have uniform fine-textured profiles that crack open significantly when dry and have some form of gilgai microrelief. The surface soils range from grey and grey-brown (Ug 5.2 and Ug 5.5) to brown and red-brown (Ug 5.3) clays that may be finely structured and self-mulching (Ug 5.2, Ug 5.3) or coarsely structured and not self-mulching (Ug 5.5). The surface soil grades below 30-50 cm into lenticular or parallelepiped peds with smooth, often glossy surfaces. Below depths ranging from 30 cm to about 1 m there are either colour changes in the clay or marls and weathered parent rock occur. They are usually deep soils, and are classed as Ug 5.2, Ug 5.3 and Ug 5.5 on the Factual Key.

Distribution. Chromic Vertisols make up the largest area of clay soils in Australia and are particularly widespread on the inland plains and rolling downs of eastern Australia, extending in an arc from north to south. Parent materials include alluvium and various sedimentary rocks, such as mudstones, and other that can weather to high clay contents and have at least moderate base status.

Land use. The greater areas of these soils are natural grasslands and shrublands that have been used for cattle and sheep grazing for a long time. Grain production, especially wheat and sorghum, is increasing where the climate permits, and where irrigation is possible rice, cotton, sown pastures and feed crops are grown.

Vp. PELLIC VERTISOLS

Soil characteristics. Pellic Vertisols in Australia have uniform fine-textured profiles that crack open significantly when dry and have some form of gilgai microrelief. The surface soils are dark, black or near-black clays that may be finely structured and self-mulching (Ug 5.1) or coarsely structured and not self-mulching (Ug 5.4). The surface soil grades below 30-50 cm into lenticular or parallelepiped peds with smooth, often glossy surfaces. The dark clay ranges from 30 cm to about 1 m in depth, and is underlain by marls, weathered parent rock or clays that may be brownish in well-drained sites, greyish in less well-drained sites, and highly mottled in poorly drained sites. The more manageable and fertile of these soils are classed as Ug 5.1, and the less tractable as Ug 5.4 on the Factual Key.

In New Caledonia Pellic Vertisols have very dark grey fine-structured A horizons, grading into very firm grey B horizons with well-developed large prismatic structures. Slickensides are numerous and cracks are up to 2 cm wide.

Distribution. These soils are widely distributed in Australia on coastal plains, inland plains and rolling to low hilly upland on a variety of parent materials, including alluvium and basalts, that can weather to high clay contents and have moderate to high base status.

In New Caledonia they occur on old alluvial plains derived from basic or ultrabasic rocks, or on basic rocks on easy slopes. They are extensive along the west coast of the island.

Land use. Their most important use is for grain production under dry farming, and for the grazing of native pastures by cattle and sheep. The range of crops grown is wide, and as well as wheat and sorghum includes cotton, lucerne and rice.

In New Caledonia these soils are mainly under rich natural pasture on soil from basic rocks, poor on soil from ultrabasics. Intensive pasture development has been readily successful on the soils from basic rocks. The economic development of the soils from ultrabasic rocks has not yet proved possible.

W. Planosols

Wd. DYSTRIC PLANOSOLS

Soil characteristics. In Australia these soils have texture contrast profiles with low base saturation. They occur with Solodic Planosols, which are very similar. The A horizons are brownish grey to grey-brown sands, sandy loams or loams. They pass clearly to the near-white E horizons of similar texture. The A horizons, which may be hardsetting, range from 10 to 60 cm in thickness, and have an abrupt boundary with the subsoil. The B horizons range from brown and yellow-brown to yellow. Some are mottled. They may be massive or have blocky or prismatic structure. They pass gradually into C horizons at depths varying from 0.6 to 1 m. These acid soils are classed as Dr 3.41, Dy 2.41, Dy 2.42, Dy 3.41, Dy 3.81, Dy 5.41 and Dy 5.81 on the Factual Key.

Distribution. The soils, with Solodic Planosols, are widespread in Tasmania and in the hinterlands of northern, eastern, southern and southwestern Australia on hillslopes, plains and terraces, and are developed widely on clayey and medium-textured colluvium and alluvium, but there are also sedentary members developed on a range of igneous, sedimentary and metamorphic rocks as well as on truncated remnants of materials weathered in earlier times.

Land use. These soils are generally used for the grazing of sheep and cattle on volunteer and sown pastures, but there is some cropping and also some horticulture, mainly apples and pears.

We. EUTRIC PLANOSOLS

Soil characteristics. These texture contrast soils are essentially the same as Solodic Planosols, except that the clay B horizons contain less than 6 percent exchangeable sodium. The A horizons vary from dark brown to dark grey sandy loams, loams or clay loams. There is a gradual change to the prominent near-white (bleached) E horizons. The thickness of these hardsetting A horizons usually ranges from 10 to 20 cm, and there is a clear to abrupt boundary with the subsoil. The B horizons are brown clays that are uniformly coloured or mottled, and have prismatic or, less commonly, columnar structure. They pass either into clays with weathered parent rock or variously mottled clayey colluvium or alluvium at depths of 0.5 to 1 m. These moderately acid to neutral soils are classed as Db 1.42 and Db 2.42 on the Factual Key.

Distribution. These soils, in association with Solodic Planosols, occur extensively in small areas throughout eastern Australia, but reach their largest individual area of development in Tasmania, where they have formed on dolerite, or colluvium and alluvium derived from it.

Land use. These soils are mainly used for the grazing of sheep and cattle on native, volunteer or sown pastures, but large areas remain under natural forest which contains millable timber.

Wh. HUMIC PLANOSOLS

Soil characteristics. Humic Planosols in Australia have texture contrast profiles with dark surface soils over bleached subsurfaces. The A horizons are dark brownish grey loamy sands or sandy loams that grade into prominent near-white (bleached) E horizons. These hardsetting A horizons are 40-80 cm thick and have an abrupt to clear boundary with the subsoil. The B horizons are mottled light grey or light bluish grey clays with varying amounts of yellowish or reddish mottles and rusty rootlines. Structure is blocky to prismatic and peds have bluish grey faces. With depth mottling becomes prominent, and structures become finer as the subsoil passes into clayey colluvium or alluvium at depths of 1 to 3 m. These acid soils are classed as Dg 2.41 on the Factual Key.

Distribution. These soils occupy poorly drained situations on coastal plains in north and central Queensland.

Land use. Little development has taken place on these soils, and their native pastures provide only sparse grazing for cattle. Improved pastures are being sown in some areas with heavy fertilizer applications.

Ws. SOLODIC PLANOSOLS

Soil characteristics. Solodic Planosols in Australia have texture contrast profiles with bleached E horizons, and clay subsoils containing more than 6 percent sodium on the exchange complex. The A horizons range from brownish grey to brown and reddish brown sands, sandy loams or loams. They pass clearly to near-white E horizons. These horizons, which may be hardsetting, range from 10 to 60 cm in thickness and have an abrupt boundary with the subsoil. The B horizons vary from red-brown or red whole-coloured clays to yellow-brown or yellow mottled grey and red clays and sandy clays. These colour changes indicate variations in subsoil permeabilities, not provided for by the present classification.

The subsoils have blocky or prismatic structures, or may be massive, and pass gradually into C horizons. Soils are usually 0.6 to 1 m thick. These acid to neutral soils are classed as Dr 2.41, Dr 2.42, Dy 3.42, Dy 3.82, Dy 5.42 and Dy 5.82 on the Factual Key.

Distribution. These soils are widespread in the hinterlands of northern, eastern, southern and southwestern Australia and in Tasmania on hillslopes, plains and terraces.

They are developed widely on clayey to medium-textured colluvium or alluvium, but there are also sedentary members developed in a range of igneous, sedimentary and metamorphic rocks as well as on truncated remnants of materials weathered in earlier times.

Associations with Orthic Solonetz (with calcic horizons) are widespread in the hinterlands of northern, southern and southwestern Australia, on plains and terraces where they have developed on clayey, calcareous colluvium and alluvium.

Land use. These soils mainly provide grazing for sheep and cattle on volunteer and improved pastures, but wheat is grown also, and there is some horticulture, principally apples and pears.

X. Xerosols

Xh. HAPLIC XEROSOLS

Soil characteristics. Haplic Xerosols have uniform medium-textured profiles. The immediate surface soil may be platy, while below this there is normally a weak development of subangular blocky structure. When dry, the soil powders readily if subjected to slight pressure. The surface soil is slightly darkened by organic matter, and changes from reddish brown to a lighter brown at depth. Textures range from silty fine sandy loams to silty clay loams. Soft carbonate frequently occurs in pockets below 15 cm.

Soil depth varies from less than 0.6 to more than 1 m. These soils are classed Um 5.2 on the Factual Key.

Distribution. These soils occur mainly in the northwest of Western Australia, on limestones and on alluvium derived from limestones.

Land use. These soils are mainly used for the grazing of the natural herbage by sheep and cattle, but on the levees and floodplains of the Gascoyne river tropical fruits, especially bananas, and vegetables are grown under irrigation.

Xk. CALCIC XEROSOLS

Soil characteristics. In Australia these soils include a wide range of calcareous soils, from relatively shallow forms with uniform, medium-textured profiles, to relatively deep soils with texture profiles that become increasingly clayey with depth. All are calcareous throughout the profile and either have a zone of carbonate segregation and accumulation in the subsoil or are sedentary on calcretes. They have well-developed pallid A horizons, which range from grey-brown to dull reddish brown. Colours become paler and, in the deeper soils, yellowish with depth. Surface soil textures are loams in the shallower soils, but range from sands to loams in the deeper soils with subsoils becoming sandy clay loam, sandy clay or clay. Soluble salt contents vary from moderately low to high. These soils are classed as Um 5.11, Um 5.61, Gc 1.12, Gc 1.22, Gc 1.21 and Gc 2.22 on the Factual Key.

Another group of Calcic Xerosols, all rather shallow soils, occurs in close association with Haplic Xerosols. They are classed as Um 6.22, Um 6.23 and Um 6.24 on the Factual Key, and are found extensively in the semiarid to seasonally humid areas, particularly of western, northern and southern Australia wherever suitable parent rocks occur. These are mainly limestones, calcretes, dolomites and some intermediate and basic igneous rocks.

Distribution. The main group of Calcic Xerosols are particularly widespread in the arid to semiarid regions of central southern Australia, with smaller areas in the arid to semiarid areas of western and central Australia and western Queensland. They are formed from calcareous sediments or rocks.

Land use. These soils are most extensively used for the grazing by sheep and cattle of the natural herbage. Where rainfall is 250 mm or more, cereals are grown, particularly wheat. Along the Murray river, and in other areas where irrigation is available, horticulture, viticulture and pastures have been developed.

Y. Yermosols

Yh. HAPLIC YERMOSOLS

Soil characteristics. Haplic Yermosols in Australia have uniform medium- or fine-textured profiles. A horizons are lacking or only very weakly present. These soils range from brown to red-brown and red loams and sandy clay loams to clays. They are all massive and porous, and most tend to be powdery when dry. Soil depth varies from 10 cm to 1 m.

Some members have a red-brown siliceous hardpan below the solum and others contain ironstone gravels throughout the profile. Soluble salt contents are very low. These soils are classed as Um 5.3, Um 5.51, Um 5.52 and Uf 6.71 on the Factual Key.

Distribution. These soils are widespread in the arid areas of Western Australia, eastern central Australia and western Queensland. They are developed on colluvial and alluvial mantles derived from truncated remnants of old laterite profiles and overlying granites, gneisses and basic igneous rocks.

Land use. These soils are used for the sparse grazing of sheep and cattle on natural vegetation.

Yl. LUVIC YERMOSOLS

Soil characteristics. Luvic Yermosols in Australia have texture profiles that become increasingly clayey with depth. Surface soils, which show very weak A horizon development, range from grey through grey-brown to red-brown loamy sands to clay loams. Below these surfaces, which are about 10 cm thick, the soil consists dominantly of red-brown, yellow-brown or yellow massive, porous, earthy material, in which clay contents gradually increase with depth, usually reaching sandy clay or clay, but sometimes only sandy clay loam in the sandier members. Ironstone gravels occur commonly in these soils, while in some there are subsoil segregations of carbonates. Soluble salt contents are usually low. They are classed as Gn 2.11, Gn 2.12, Gn 2.13, Gn 2.21, Gn 2.22, Gn 2.61, Gn 2.62 and Gn 2.63 on the Factual Key.

Distribution. Luvic Yermosols are particularly widespread in the arid to semiarid regions of Australia, except for central southern Australia. They are derived from a range of parent materials with high silica content, including granites, granodiorites, sandstones, acid volcanic rocks and unconsolidated sandy sediments.

Land use. In dry areas these soils are used for the grazing of natural vegetation by sheep and cattle. Cereal cropping and improved pastures have been developed in the wetter areas, while specialty crops are grown where water is available for irrigation.

Z. Solonchaks

Zo. ORTHIC SOLONCHAKS

Soil characteristics. These soils, which occur in close association with Gleyic Solonchaks, have uniform, medium-textured profiles. The surface soils range from grey to grey-brown sandy clay loams or loams which merge into light grey-brown, yellowish red or red-brown subsoils. Some are calcareous throughout the soil mass and others contain gypsum, but all have very high contents of soluble salts. They are classed as Um 1.1 and Um 1.2 on the Factual Key.

Distribution. Orthic Solonchaks occur in young riverine alluvia in the semiarid to arid regions of Western Australia and western central Australia.

Land use. Most areas remain unused except for the incidental grazing of the natural vegetation by sheep and cattle.

Zt. TAKYRIC SOLONCHAKS

Soil characteristics. Takyric Solonchaks have uniform fine-textured profiles. There may be an encrustation of salt on the soil surface. The surface soils range from dark grey to dark grey-brown clays. Subsoil colours vary a great deal from yellowish and reddish to bluish-grey; again some are mottled, and of these some have pale yellow mottlings indicating high acidity but all are high in soluble salts. The subsoil clays are massive and plastic but some surfaces may have platy structure. They are classed as Uf 1.4, Uf 6.5 and Uf 6.6 on the Factual Key.

Distribution. These soils occur on the saline alluvia of the coastal plains of northern Australia.

Land use. These soils are usually not used except for some grazing of natural vegetation by sheep and cattle.

Conclusions

The Soil Map of the World indicates very broadly the nature and distribution of the main soils of the great regions. In Australasia and the Pacific soil maps more detailed than this have been prepared for most of the islands and for many parts of Australia. However, in the Soil Map of the World a common legend is used for all the region, and for the first time the full spectrum of soils and their relationships can be seen. Comparisons with soils of other regions will also be possible when the entire Soil Map of the World is published.

The nations of the Pacific now have the broad pattern of their soils outlined, and they are able to establish correlations between their own detailed soil units and the international units. The way is thus open for a much more effective exchange of information on soil and land use. It will also be possible to establish international research programmes aimed at the solution of soil and land-use problems in a much more practical and rational manner.

The soils of the Pacific region are highly varied in nature and distribution, and generalization is difficult. However, most countries appear to have soil resources which, in conjunction with very favourable climates, are capable of substantially greater levels of production than are achieved at present. Reaching the full potential of soils will not necessarily be easy, as some very real limitations exist. These include problems of nutrients, of degradation and erosion, of drainage or irrigation, of stoniness and depth, and of cultivation and management. These, and others, will have to be overcome by practical study and research throughout the region in coming years.

The Soil Map of the World is only a start, but it has provided a common language for soil scientists and it is hoped that it will now provide a sound base for the development of soil science and its application, not only throughout Australasia and the Pacific but throughout the world.

7. SOILS OF OTHER PACIFIC REGIONS

Sheet X2 of the Soil Map of the World covers the southwestern Pacific approximately from the equator to latitude 48°S and from Australia to 180° longitude.

In total area this sheet covers less than 10 percent of the 175 million sq km of the Pacific basin. In land area, however, it includes all but 2 percent of the 860 000 sq km total.

In this chapter an account will be given of the soils of the remaining 2 percent, small but important areas of land scattered as small islands over a vast ocean.

The soil data are given in Table 11, in which the island groups are listed systematically, after Douglas (1969): East Pacific, Polynesia, Micronesia, Melanesia, Nontropical.

The table is similar to Table 10 in Chapter 5, and the soil associations have been established and numbered in the same way as those shown on the map sheets. The islands covered in Chapter 5 have been omitted.

The sources of information and other important papers are listed at the end of this chapter.

East Pacific

In the east Pacific there are nine island groups composed of 57 islands or islets. Most of these (45) are in the Galapagos group which has been included in the Soil Map of South America. The others are nearly all small, extremely rugged, barren and inaccessible; few are inhabited. The dominant soils are probably Lithosols and Regosols, although more strongly developed profiles are likely on localized stable sites.

Polynesia

The islands of Polynesia extend from Easter Island in the east across to the Ellice Islands in the west and to Hawaii in the north.

There are 287 islands, of which more than half are known to be inhabited.

ATOLLS

Most of the islands are atolls where the soil pattern is relatively simple. Calcaric Regosols, very weakly developed soils on coral sand and rubble, are dominant. In hollows the soils may show hydromorphic properties, including increased organic matter, but these are too weakly expressed to affect the classification, and the areas are small.

On some islands a soil named the Arno series, described by Stone (1951), is found in association with the Calcaric Regosols (Shioya series). The Arno soils have a deep black granular A horizon flecked with white sand, on coral sand. Another soil, described by Fosberg (1954), is the Jemo series, formed under *Pisonia* trees and characterized by an acid litter over a layer enriched with phosphate.

In other places there are small areas of peat, mangrove swamps, and areas enriched with volcanic ash or sea-borne pumice. In drier areas salt levels may be high.

Soils moist and rich in organic matter (compost or taro pits) have been developed specifically for growing crops, and in places soil from other islands has been imported for such gardens. However, these variants appear to be small in area and have not been added to the Calcaric Regosol association. Neither have other possible phase separations, apart from the stony and lithic phases which are clearly widespread.

The petrocalcic phase occurs where recementation of loose carbonate has taken place under a wetting and drying climatic regime.

Hardpans of calcium phosphate are also found, particularly in association with the Jemo series, but these are considered as parent material, not as a characteristic of the soil profile.

Salt is a factor of considerable importance. When blown in the wind it may strongly affect vegetation patterns. In hurricanes whole islands can be completely drenched in salt water and all vegetation may be killed. Usually, however, salt is quickly washed out of the extremely porous soils and its soil effects are transitory.

Hurricanes may also have profound physical effects on atoll soils. Whole islets may be washed away or new ones formed. Trees may be uprooted and exposed soils washed or blown from place to place. Atolls severely affected may be made uninhabitable for many years until the productive plants recover or new ones grow.

A number of biological factors have been noted by writers on atoll soils. The burrowing and mixing activities of crabs are significant in incorporating organic residues into the topsoil. Birds are extremely important suppliers of nitrogen and phosphorus, particularly in the early stages of soil formation. Man came much later, but in a relatively short time has had profound effects. He has removed much of the forest, introducing food plants such as coconuts and breadfruit with attendant weeds, he has driven away birds and reduced their inputs of plant nutrients, he has exported large quantities of copra, which is high in phosphorus, he has burnt organic matter, and has transferred valuable organic and mineral resources into the sea in sewage. These losses have still to be calculated, but it is likely that fertilizers will play an increasing role in the future of atoll agriculture.

HIGH ISLANDS

The greatest land area in Polynesia is found in the high volcanic islands. These are characteristically steep and rugged with thin soils, often severely eroded. However, many have coastal terraces or lowlands with soils from coral and/or volcanic materials which are, or could be made, highly productive.

Soil surveys have been made of Easter Island, Pitcairn, the Cook Islands and Niue. Information from the other groups comes from environmental data and limited observations of soils.

Micronesia

Micronesia has 10 islands or island groups, totalling 161 islands, of which many are atolls. It extends from the Bonin Islands, near Japan, to the Marshall Islands, beyond longitude 170°E, and south to the equator.

As in Polynesia the greatest land area is in the high volcanic islands, particularly in Guam (550 sq km) and Babelthuap (450 sq km) and in five other islands with areas of about 100 sq km. The soils on most of the large islands have been surveyed. It is probable that throughout the region Lithosols dominate the very steep rocky areas, Cambisols the steep areas and Ferralsols and Nitosols the more stable areas. All the coral atolls are put in the Calcaric Regosol association.

Melanesia

All the island groups of Melanesia are shown on map sheet X2. Only three islands — Hunter, Matthew and Rotuma, the latter an island of Fiji to the far north of the group — are excluded.

Rotuma is a volcanic and coral limestone island of 5 000 ha, rising to 250 m. It is hot and humid, with a moderately well-distributed rainfall of 3 500 mm, well wooded on the upper slopes and intensively cultivated for subsistence crops and copra on the lower slopes. The cultivated soils are deep, medium textured and highly productive. The forest soils are thin and stony. No soil survey has been made.

Nontropical islands

The 69 nontropical islands of the northern hemisphere are close to the continents, and their soils are shown on sheet II1 (the Aleutians and the islands in the Bering strait) and sheet VIII3 (Commander Islands).

In the southern hemisphere there are 40 islands, the first of which are the 15 subtropical islands of the Lord Howe, Norfolk and Kermadec groups. The soils of Norfolk Island and Raoul Island (Kermadec group) have been surveyed, the others have not, although observations by visitors have been recorded.

The New Zealand off-shore islands, including the Chatham group, are shown in sheet X2; so also are Lord Howe and Norfolk.

Finally there are the 17 subantarctic islands in 6 groups to the south of New Zealand and Australia. Most of these have been visited by scientific expeditions and some soil descriptions have been published.

Antarctica

Bordering the Pacific ocean to the south is the continent of Antarctica, a land mass of 13 million sq km, nearly 10 percent of the land surface of the earth.

Lying almost entirely within the Antarctic circle it has not been included in the Soil Map of the World because it has no soils with any agricultural potential. Most of the surface is covered by ice sheets up to 4 000 m in thickness.

However, while the soils have little agricultural interest, they have substantial scientific interest as products of soil formation in an extreme environment.

The ice-free areas in which soils have developed have been calculated to cover about 250 000 sq km, mainly around the coast where the ice sheet thins on the Antarctic peninsula, and along the Trans-Antarctic

TABLE 11. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR OTHER PACIFIC REGIONS

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Polynesia								
B2-3bc	I			130	Humid, tropical; occasional dry periods	Marquesas Islands	Forest with clear altitudinal zones, often overgrazed by feral goats, sheep, etc.; subsistence cultivation by small population	Group of 6 large and 6 small high volcanic islands; 1 260 m
B3-3ab	I Rc		Lithic, stony	14	Humid tropical (Rapa is temperate)	Austral Islands: Rapa	Forest; now much depleted by burning and feral animals; extensive cropping	Five high volcanic islands, most with reefs, a raised volcanic-coral island, and an atoll; 633 m
Bd64-3abc	Bc	Rc Je	Lithic	5	2 000 mm; 24°C; weakly seasonal	Cook Islands: Mangaia	Forest, scrub and fern; now food crops on suitable soils	Central volcano of basaltic agglomerate and dikes, surrounded by raised-coral limestone platform; 170 m
Bd65-3c		Je Rc	Stony	6.5	2 000 mm; 24°C; weakly seasonal	Cook Islands: Rarotonga	Forest, with much second growth; now food crops on suitable soils	Central volcano of basalt and phonolite agglomerate and lava, surrounded by narrow raised limestone platform; 650 m
Be110-3c	Bf Bd	I	Stony	0.45	Humid, tropical; 1 700 mm; 22°C; slightly seasonal	Pitcairn Island	Forest; now scrub and grassland with subsistence cropping	Mainly basaltic flows and pyroclastics; volcanic island; 340 m
Bh22-3a	Fo E			6	2 500 mm; 27°C	Wallis Island	Open forest, scrub and fern; subsistence cropping, coconuts	Basalt, limestone; low volcanic island with coral reef; 150 m
Bh23-3c	Fo			9.3	2 500 mm; 27°C	Futuna, Alofi	Forest, some grassland above 500 m; subsistence cropping, coconuts, timber	Basalt, some limestone; high volcanic island with coral reef; 760 m
Bv16-2b	Nd		Stony, lithic	18	Humid, slightly cool tropical; slightly seasonal; 1 200 mm; 20°C	Easter Island	Grasses, some shrubs; now subsistence cropping, sheep grazing	Basaltic and andesitic lava and ash; volcanic island, numerous cones; 600 m
I-B-Rc-ac				160	Humid equatorial; dry season of 2 months	Society Islands	Forest; cultivation mainly in coastal lowlands	Group of 9 high volcanic islands and 5 atolls; 1 323 m
I-B-Rc-3c				2	2 000 mm; 24°C	Gambier Islands (Mangareva)	Scanty flora, mainly grassland with some fruit and vegetable production in valleys	Group of 8 high volcanic islands and 2 coral islands within a barrier reef, and 1 atoll; 440 m
I-Bf-Fr-3a			Lithic	26	Humid tropical; 2 000 mm; 25°C; weakly to moderately seasonal	Niue Island	Forest; now much secondary forest and scrub, subsistence cropping, with some exports	Hard coral limestone with some volcanic and/or ocean sedimentary material; elevated coral atoll; 60 m
I-Rc-1a				2.8	Humid, equatorial	Tuamotu Archipelago: Makatea	Forest; now extremely depleted	Raised coral island; karstic; previously mined for phosphate; 110 m
Lk20-3a	Rc Ao	Af	Lithic, stony	2.6	2 400 mm; 25°C; weakly seasonal	Cook Islands: Atiu	Forest and scrub; now coconuts, some food crops	Central hill of deeply weathered basalt; surrounded by raised coral platform; 80 m
Ph13-3ab	Rc Hl			1.6	1 750 mm; 26°C; moderately seasonal	Cook Islands: Aitutaki	Forest; now food and tree crops	Basalt agglomerate and conglomerate with fringing coral sands; 70 m
Rc1-1a			Stony, lithic	3	Humid equatorial; 2 000 mm; dry months may occur June-Sept.	Cook Islands: Atolls	Many of islands well wooded, coconut groves; some subsistence cropping	Nine atolls; 5 m

TABLE 11. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR OTHER PACIFIC REGIONS (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Rc1-1a			Stony, lithic	60	Humid equatorial	Tuamotu Archipelago: low islands	Many of islands well wooded, numerous coconuts; subsistence cropping in inhabited areas	Group of 75 coral atolls and islands; up to 5 m
Rc1-1a			Stony, lithic	1	Humid equatorial; 2 500 mm; 26°C; highly variable rainfall	Tokelau Islands	Forest; subsistence cultivation, coconuts	Three coral atolls; 5 m
Rc1-1a			Stony, lithic	2.5	Humid equatorial: 2 600-3 700 mm: 28°C; well-distributed rainfall increasing to south	Ellice Islands	Scrub and forest: subsistence gardening, coconuts	Nine coral atolls; 5 m
Rc1-1a			Stony, lithic	3	Dry equatorial; rainfall highly variable < 600 mm with long droughts in north, south less dry with 1 300 mm	Phoenix group	Scrub and trees, coconuts on most islands; only Canton Island inhabited	Eight atolls; previously extensive phosphate workings: 5 m
Rc1-1a			Stony, lithic	43	Dry equatorial; Palmyra-Fanning, Caroline-Flint groups in moist zones	Equatorial (Line) Islands	Scrub and trees; some coconut plantations, most islands uninhabited	Fourteen atolls; previously extensive phosphate workings; 5 m
Rc1-1a			Stony, lithic	1.2	Humid, tropical	Hawaii: atolls	Trees and scrub: now severely depleted by rabbits, some recovery; mostly uninhabited	Six atolls: some phosphate worked: extensive changes from construction of military installations; 5 m
Rc16-1a	I		Lithic	3	Probably similar to nearby Pitcairn Island	Islands of Henderson, Ducie and Oeno	Forest; some coconuts	Coral islands; Henderson raised 30 m, others atolls
Rc44-1a	Ao Af		Lithic, stony	1.8	1 900 mm; 25°C; weakly seasonal	Cook Islands: Mauke	Forest; now food crops	Central low-lying flattish volcano, surrounded by wide raised coral platform: 30 m
Rc45-1a		Lk	Lithic, stony	1	1 900 mm: 25°C; weakly seasonal	Cook Islands: Mitiaro	Forest; now coconuts, some food crops	Central low-lying volcano, surrounded by raised coral platform; 6 m
East Pacific								
B2-3c	I		Lithic	26	Dry, tropical	Guadelupe	Endemic oak, pine, cypress and palms in north, barren in south	High volcanic peaks; 1 230 m
B2-3c	I		Lithic	1.7	Equatorial	Cocos Islands	Evergreen forest, some coconuts along beach	Basalt; mountainous volcanic island; 810 m
B109-2c	Bv I		Lithic	15	Subtropical oceanic: up to 1 000 mm rainfall	Juan Fernandez Islands	Strongly altitudinally zoned with scrub thickets, evergreen forests, cloud forest and alpine meadow	High steep volcanic islands; 1 000 m
I-B-c					Dry, subtropical	Islas de los Desventurados	Open dryland vegetation	High basalt islands, steep cliffs: 450 m
I-Re-1c			Lithic	0.1	Equatorial	Malpelo Island	Barren, some scrub in gullies	Volcanic island; precipitous slopes: 260 m
Rc1-1a			Stony, lithic	0.25	Dry, tropical	Clipperton Atoll	Low scrub, grass, with some coconut groves	Coral atoll with 29-m volcanic plug; phosphate has been worked
Re24-1c	I		Lithic	15	Dry, tropical	Revilla Gigedo Islands, Alijos rocks	Grass, scrub and some trees in valleys	Basaltic ash, scoria and rock; volcanic islands; 1 130 m

TABLE 11. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR OTHER PACIFIC REGIONS (*continued*)

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Micronesia								
B4-abc	I R			7.2	Humid, slightly cool tropical	Bonin Island	Forests: some removed for cultivation, but there are now few inhabitants	Group of 24 small volcanic islands, some with limestone: 460 m
Be111-3abc	I Ne		Stony	12.3	2 000 mm: 28°C: weakly seasonal	Mariana Islands: Saipan	Forest, grasses: now subsistence cropping	Limestone: volcanics: volcanic island with much limestone: 470 m
Be111-3a	I Ne		Stony, lithic	10.2	2 000 mm; 28°C: strongly seasonal	Mariana Islands: Tinian	Forest, grassland with trees and shrubs: now subsistence cropping	Limestone, andesitic pyroclastics: volcanic island with much limestone: 180 m
Be112-3ab	I Rc			0.4	3 000 mm: 27°C; slightly seasonal	Caroline Islands: Palau district	Forest, often dense with many species: now subsistence cropping, copra production	Fifteen small islands, main area is raised limestone, but there are 7 atolls and small volcanic areas: 200 m
Be113-3b	Fo	Lp Je Oe		10	3 000 mm: 27°C: moderately seasonal	Caroline Islands: Yap district, Yap Island	Forest: now some grass and scrub, some subsistence cropping and copra production	Metamorphics and ultrabasic intrusives, andesites, basalts: an island group with little coral: 180 m
Be114-3b	Fo	Rc		44	5 000 mm: 27°C; weakly seasonal	Caroline Islands: Ponape district, Ponape, Kusaie	Densely forested in mountains, narrow coastal plains cultivated, some timber production	Two high volcanic islands with fringing reefs: 800 m
Fo99-3c		Rc Oe Gh	Stony, saline	10	4 000 mm: 27°C: weakly seasonal	Caroline Islands: Truk district, Truk group	Forest, many coconuts, breadfruit; now subsistence cropping	Group of 19 high volcanic islands and 65 islands within a reef: 440 m
Fr30-3bc	I	B Oe Rc		49	3 500 mm: 27°C: slightly seasonal	Caroline Islands: Palau district, Babelthuap	Forest: now much grass and scrub and some subsistence cropping	Basalt, andesite and dacite, limestone: volcanic islands, raised limestone, reefs: 240 m
I-a				0.6	1 600 mm: 28°C: rainfall highly variable from year to year	Gilbert and Ellice Islands, Ocean Island	Forest and scrub, coconuts: now 66 percent of surface cleared by mining operations, no agriculture	Coral limestone: phosphate rock: raised coral island; 85 m
I-B-3ab			Stony	55	2 000 mm: 27°C: long dry season	Mariana Islands: Guam	Forest: much secondary growth, some subsistence cultivation, large areas of defence installations	Raised limestone plateau in north, with some old, deeply weathered pyroclastics and lavas in south: 400 m
I-R-B-1bc				3	Humid, slightly cool tropical	Volcano Islands	Forest, scrub, grasses: probably none now inhabited	Group of 3 volcanic islands; still some volcanic activity on Iwo Jima: 1 000 m
Rc1-1a			Stony, lithic	1	Tropical, rainfall 1 000 mm, with strong dry season	Marcus and Wake	Forest: now scrub, soils much disturbed by military and airport construction	Two atolls; 4 m
Rc1-1a			Stony, lithic	2.8	3 000 mm: 27°C: weak to moderate dry season	Caroline Islands: Truk district	Trees and scrub, many coconuts: subsistence cropping	Ten atolls: 5 m
Rc1-1a			Stony, lithic	1.1	3 000 mm: 27°C: weakly seasonal	Caroline Islands: Panape district	Forest and scrub: now mainly planted in coconuts: some subsistence cultivation	Eight atolls: 5 m

TABLE 11. — SOIL ASSOCIATIONS AND RELATED INFORMATION FOR OTHER PACIFIC REGIONS *(concluded)*

Map symbol	Associated soils	Inclusions	Phase	Extension (1 000 ha)	Climate	Occurrence	Vegetation	Lithology
Rc1-1a			Stony, lithic	18	2 000 mm; 27°C; severe droughts may occur; rainfall much less in north, much more in south	Marshall Islands	Forest on many islands, also scrub and grasses; many coconuts, subsistence cultivation	Thirty-three atolls in two chains; 5 m
Rc1-1a			Stony, lithic	3	1 100 mm in south, 3 000 mm in north; 28°C; strongly seasonal	Gilbert Islands	Forest and scrub; now many coconut groves, subsistence cropping	Sixteen atolls; 5 m
Rc1-1a			Stony, lithic	1.9	3 000 mm; 27°C; weakly to moderately seasonal	Caroline Islands: Yap district	Well wooded, many coconut groves; subsistence cropping	Group of 16 atolls and a raised (20 m) atoll; some phosphate deposits have been worked
Re80-ac	I	Tv	Lithic, stony	4.8	2 000 mm; 28°C; strongly seasonal	Mariana Islands: Pagan	Forest, grassland, with trees and shrubs; now subsistence cultivation, coconuts	Basaltic lavas and pyroclastics; active volcanic island; 570 m
Re81-c	I B	Rc		20.5	2 000 mm; 28°C; strongly seasonal	Mariana Islands	Forest, scrub; some subsistence cultivation on inhabited islands	Eleven volcanic islands, some active volcanoes; some raised limestone areas; 1 000 m
Melanesia								
R4-1c	T		Stony	5	3 500 mm; 27°C; well-distributed rainfall	Fiji: Rotuma	Upper slopes wooded; subsistence cultivation, coconuts, cotton	Basalt, limestone, coral sand; volcanic island with coral reef; 250 m
Re30-1c	Tv I			0.04	2 000 mm; 23°C	Hunter Island, Matthew Island	Grass, scrub; uninhabited	Active volcanic islands; 300 m
Nontropical islands								
Bd60-1ab	Od		Stony	12	Humid, cold temperate; 930 mm; 4.5°C	Macquarie Island	Tussock grassland, subglacial herbfield, fen, bog and feld mark	Basic igneous rock, stony glacial till and peat; a plateau of 300 to 400 m rising abruptly from sea; maximum elevation 430 m
I-1abc				0.15	Humid, cold temperate	Bounty Islands	Bare rock	Group of small granite islets and stacks, often with crust of guano
Od18-ab		I		0.25	Humid, cold temperate	Snares Islands	Forest covers most of centre of islands, grasses between centre and cliff tops	Granite, standing about 100 m above sea, rising to maximum of almost 200 m
Od18-ab		I		56	Humid, cold temperate; 1 800 mm; 10°C	Auckland Islands	Forest, scrub and tussock grasses	Basalt with extensive peat cover; 650 m
Od18-ab		I		15	Humid, cold temperate; 1 450 mm; 7°C	Campbell Island	Forest, scrub and tussock grasses	Basalt with extensive peat cover; volcanic island; 570 m
Re38-1ab		I		6.2	Humid, cold temperate	Antipodes Islands	Scrub and tussock grasses	Recent basaltic lavas and scorias, volcanic islands; rich in phosphorus; 400 m
To1-3a				0.3	1 500 mm; 19°C; well-distributed rainfall	Kermadec group: Macaulay	Grasses; uninhabited	Andesitic volcanic ash and mud; 240 m
Tv33-1c	Re		Stony	3	1 500 mm; 19°C; well-distributed rainfall	Kermadec group: Raoul, Curtis	Forest; meteorological station gardens	Andesitic pumice and ash from active volcano; 520 m

mountains where glaciers have disappeared from valleys.

The main features of the environment that control soil formation are climatic, in particular very low precipitation, very low temperatures, and high summer insolation. The soils are desert soils, high in soluble salts, approaching (but not usually reaching) complete zero in organic matter, and, except on extremely old sites, very weakly weathered.

A classification of soils in Antarctica has been presented by Campbell and Claridge (1968). They named the zonal soils Frigic soils, and recognized three degrees of development depending on available moisture status, and made further subdivisions on the basis of parent material. They also classified four intrazonal soils: evaporite soils formed under the influence of saline ground water; algal peats formed in accumulations of algal material; avian soils formed in penguin nesting sites; and hydrothermal soils formed near fumaroles under the influence of hydrothermal waters.

Finally an azonal soil — a recent soil found on beaches, fans, stream beds, etc. — was listed.

In terms of the Soil Map of the World legend the dominant soils would certainly be Orthic Solonchaks, soils with a salic horizon but no other diagnostic horizons. Where the salic horizon is absent the soils would be Gelic Regosols, soils with no diagnostic horizons but with permafrost within 200 cm of the surface. Very shallow soils are commonly found on steep slopes and these would fall in the Lithosol group. The association would thus be Orthic Solonchaks dominant, with inclusions of Lithosols and Gelic Regosols, all stony phase.

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APPENDIX

MORPHOLOGICAL, CHEMICAL AND PHYSICAL PROPERTIES OF AUSTRALASIAN AND PACIFIC SOILS: DATA FROM SELECTED PROFILES

In this appendix data are presented on profiles typical of major soil units of the Australasian-Pacific region. The profiles were selected from a large amount of material, published and unpublished, assembled for the project. The source of the data for each profile is acknowledged.

The purpose of the descriptions and tables is to help define more clearly the nature of the soil units. Naturally the description and analyses of one profile cannot show the range of characteristics within such broad units, but combined with the definitions in Volume I and the descriptions and analyses in the other eight volumes they should contribute to an understanding of the concepts on which the legend is based.

The data have been set out systematically to include items generally available in soil survey reports. The material is presented according to the standards of the FAO *Guidelines for soil profile description* (FAO, 1968), and the U.S. Department of Agriculture *Soil Survey manual* (1951).

Analytical methods

The analytical methods used in different laboratories in the region are very similar, and figures for pH, organic matter, cations and particle size distribution can be compared with some confidence.

The methods used can be found in the following documents:

Australia, Papua New Guinea: Piper (1942); Stace *et al.* (1968).
Solomon Islands: Hansell and Wall (1975).
New Caledonia, New Hebrides: ORSTOM, New Caledonia (unpublished).
New Zealand: New Zealand Soil Bureau (1968); Metson (1956).
Fiji: Metson (1956); Twyford and Wright (1965).
Western Samoa: Metson (1956).
Cook Islands: Metson (1956).
Hawaii: Foote *et al.* (1972).

Presentation of data

Wherever possible the data have been taken from the original documents without alteration. However, some changes have been made for the sake of brevity and for uniformity of presentation.

SITE DESCRIPTION

The information given to describe sites is as follows:

Location: The general locality is given, with latitute and longitude in degrees and minutes.

Altitude: The altitude is given in metres above mean sea level.

Physiography: Where possible, the nature of the landscape is described and the slope at the profile site given.

Drainage: Drainage is given as a general description of the way water passes through the soil in terms ranging from very poorly drained to very well drained.

If water is impeded by an impermeable soil horizon this is indicated.

Parent material: Sometimes parent rock and sometimes underlying rock are given under this heading.

Vegetation: Usually information was insufficient to describe the plants at the site, so a general description is given of the kind of vegetation cover (e.g., savanna, forest).

Climate: The approximate mean annual rainfall is given together with a descriptive term as used in the chapter on climate. For Australian soils the index for seasonality is also added.

PROFILE DESCRIPTION

The profile descriptions have been rewritten to follow the pattern outlined in *Guidelines for soil* *profile description* (FAO, 1968). The information is given in the order: colour, texture, mottling, structure, consistence, other items. Horizon designations conform with the definitions given in Volume I. Where they were not included in the original description they have been established using the descriptive and analytical data available.

ANALYSES

Some figures have been rounded or recalculated on a different basis for the sake of uniformity.

pH in water suspension is given for all profiles; for some it is also given in *N* Kcl.

Soil: Water ratios of 1:5 are used in Australia, and 1:2.5 elsewhere.

Cation exchange: Neutral normal ammonium acetate leaching is used in cation exchange capacity determinations.

In Australia ammonium chloride is used instead of ammonium acetate for extraction of the cations, calcium, magnesium, potassium and sodium, but the values obtained by the two methods differ little (Piper, 1942). Total exchangeable bases are usually found by addition, but in New Zealand results the titration value is given.

Organic matter: The Walkley-Black and Kjeldahl methods, or variations of them, are used by all laboratories. Values for organic matter (OM) are given when these have been separately determined.

Particle size analysis: As most laboratories in the region use the international particle size ranges, these have been quoted:

coarse sand	2 000 - 200 μm
fine sand	200 - 20 μm
silt	20 - 2 μm
clay	below 2 μm

The results are calculated on the basis of organic matter-free soil with fractions coarser than 2 mm removed. The fractions above 2 mm are combined under the heading "stones" which is given as a percentage of whole soil. Dried allophane-rich soils are difficult to disperse so some of the % clay figures may be low.

Bulk density: Given in grams of oven-dry soil per cm^3 of undisturbed soil.

For Solomon Islands soils it is g/cm^3 of disturbed soil.

Available phosphorus: A variety of methods have been used, and the results have all been recalculated to give mg P/100 g soil.

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LIST OF SOIL PROFILES

Symbol and unit			*Country*	*Page*
Af	Acrisol	Ferric	New Caledonia	134
Ag		Gleyic	Australia	136
Ah		Humic	Papua New Guinea	138
Ao		Orthic	Australia	140
Bc	Cambisol	Chromic	Solomon Islands	142
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Lf		Ferric	Australia	176
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Od	Histosol	Dystric	New Zealand	186
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Qa	Arenosol	Albic	Australia	190
Qf		Ferralic	Australia	192
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So	Solonetz	Orthic	Australia	198
Th	Andosol	Humic	New Zealand	200
Tm		Mollic	Hawaii	202
To		Ochric	New Zealand	204
Tv		Vitric	Solomon Islands	206
Vc	Vertisol	Chromic	Australia	208
Vp		Pellic	Australia	210
We	Planosol	Eutric	Australia	212
Ws		Solodic	Australia	214
Xk	Xerosol	Calcic	Australia	216
Yh	Yermosol	Haplic	Australia	218
Yl		Luvic	Australia	220

FERRIC ACRISOL Af

Classification	New Caledonia: Sol fersiallitique désaturé lessivé appauvri
Reference	ORSTOM, 1970. Profile NOU 1
Location	Noumea, Paita road; 22°08'S, 166°25'E
Altitude	30 *m*
Physiography	Slope of 11 degrees in hilly terrain
Drainage	Well drained
Parent material	Rhyolites
Vegetation	Savanna
Climate	Humid tropical; 1 270 mm rainfall

Profile description

A	**0-20 cm**	Dark grey (10YR 4/1) loamy sand; weakly developed medium to fine crumb structure; loose; many fine vesicular pores; many medium to fine roots; gradual smooth boundary.
E	**20-40 cm**	Yellow (10YR 8/6) sandy loam; weakly developed fine subangular blocky structure; soft; many fine and medium pores; some medium and fine roots; gradual irregular boundary.
Bts	**40-130 cm**	Reddish yellow (5YR 7/6) clay, with numerous fine distinct yellow mottles and nets; moderately developed medium prismatic breaking to fine blocky structure; slightly sticky, slightly plastic; continuous thin clayskins on peds; the top of the horizon appears to be penetrated by the E horizon.
BC	**130+**	Red (2.5YR 5/8) clay, with numerous fine, distinct, and some net yellow mottles, the mottles larger and more contrasting with depth; rock structure conserved; *thin discontinuous ferruginous clayskins; no roots.*

FERRIC ACRISOL
New Caledonia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—15	4.6		10.7	4.1	38	1.5	1.4	0.4	0.8			
E	25—35	5.4		5.5	1.4	26	0	1.2	0.2	0			
Bts	90—100	4.8		19.3	3.4	17	0	2.7	0.3	0.4			
BC	180—200	4.6		14.2	1.5	11	0	1.3	0.2	0.1			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			2.1	0.10	21			30	28	26	16	sandy loam
E			0.5	0.04	11			22	28	28	22	loam
Bts			0.5	0.04	11			12	10	12	66	clay
BC			0.3	0.03				19	16	13	52	clay

Horizon	Solution by $HNO_3 + HClO_4$ %											
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO_2	P_2O_5						
A	15.8	6.3	2.1	0.01	0.01	0.33						
E	22 0	8.9	1.6	0.07	0.01	0.11						
Bts	33.1	23.8	3.9	0.04	0.01	0.17						
BC	26.7	19.0	3.2	0.01	0.01	0.14						

Horizon	Solution by $HNO_3 + HClO_4$ me %											
	Ca	Mg	K	Na								
A	3.6	7.1	9.3	0.8								
E	6.1	7.0	10.1	1.0								
Bts	0.4	28.5	38.7	0.4								
BC	1.1	9.6	20.6	1.6								

GLEYIC ACRISOL Ag

Classification	Australia: gleyed podzolic soils. Gn 2.94
Reference	Stace *et al.*, 1968. Profile 36A, p. 361. Beerwah Type 6
Location	Coastal lowlands, Queensland; 26°51'S, 153°01'E
Altitude	12 m
Physiography	Lower slope in low hills marginal to coastal plain
Drainage	Poorly drained
Parent material	Underlain by Mesozoic sandstone
Vegetation	Grassy forest grading to woodland
Climate	Humid subtropical; Sh; 1 625 mm rainfall

Profile description

A	**0-5 cm**	Dark grey (10YR 4/1, 5/1 dry), light brownish grey to light grey (10YR 6-7/2) patches, sand to loamy sand; structureless to weakly developed fine blocky structure; very friable; a few roots; clear boundary.
Eg1	**5-20 cm**	Light brownish grey to light grey (10YR 6-7/2) sand, with fine strong brown (7.5YR 5/8) mottles and yellowish red (5YR 4/8) flecks; massive; very friable; porous; few roots; diffuse boundary.
Eg2	**20-35 cm**	Light grey to white (10YR 7-8/2, 9/1 dry) sand, with distinct, fine yellowish brown (10YR 5/6) mottles and yellowish red (5YR 4/8) flecks; massive; very friable; few roots; diffuse boundary.
EBg	**35-50 cm**	White (10YR 8/1-2, 9/1 dry) sand, with fine yellowish brown flecks; massive; very friable; abrupt irregular boundary.
Btg1	**50-55 cm**	Light grey (10YR 6-7/1) clayey sand, with coarse prominent yellowish brown to dark yellowish brown (10YR 4-5/8) mottles; weakly developed very coarse pseudo-columnar structure; firm; porous; gradual boundary.
Btg2	**55-75 cm**	Grey to light grey (10YR 6/1) sandy clay loam, with coarse prominent yellowish brown (10YR 5/8), light yellowish brown (10YR 6/6) and reddish brown mottles; pseudo-columnar breaking to coarse blocky structure; firm; sandy tongues of horizon above separate the columns.
Btg3	**75-90 cm**	As horizon above but sandy clay texture; diffuse boundary.
Btg4	**90-120 cm**	Light grey (2-5Y 7/0-1) sandy light medium clay, with coarse prominent strong brown (7.5YR 5/6) and red (2.5YR 4/8) mottles; moderately developed very coarse blocky structure; plastic; porous; a little quartz gravel; diffuse boundary.
C	**120-160 cm**	Light grey to white (N7/0 to 10YR 8/1) medium clay, with coarse prominent yellowish brown (10YR 5/8) and red (1YR 3/6) mottles; moderately developed blocky structure; plastic.

GLEYIC ACRISOL
Australia

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—5	5.6		2	1.2	60	0.6	0.6					
Eg1	5—10	5.6		1	0.6	60	0.2	0.3		0.1			
Btg1	50—55	4.9		1	0.3	30	0.1	0.2					
Btg2	60—75	5.2		3	0.9	30	0.1	0.7		0.1			
Btg4	90—120	5.1		4	1.7	43		1.3		0.4			
C	120—150	4.9		11	3.1	30		2.5		0.6			

Horizon	Sol. salts	Organic matter				Particle size analysis %					
	Total	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.01		0.04		1.9	1	58	34	6	2	sand
Eg1	0.01		0.02		0.7	1	58	34	6	2	sand
Btg1	0.01					1	39	37	13	11	clayey sand
Btg2	0.01					1	40	34	8	18	sandy clay loam
Btg4	0.01					1	38	25	8	29	sandy clay
C	0.02					1	26	14	12	48	clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Avail. P mg %			
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO	P$_2$O$_5$							
EBg	98.3	0.6	0.1	0.4	0	0				0.3			
C	71.9	19.6	7.0	0.8	0.01	0.01	6	27	5				

HUMIC ACRISOL Ah

Classification	Papua New Guinea: Humic Brown Latosols
Reference	Haantjens *et al.*, 1967, p. 27-28. Profile MT-P16
Location	Papua highlands; 6°20′S, 144°00′E
Altitude	2 000 m
Physiography	Ridge, slope of 15 degrees
Drainage	Imperfectly or moderately well drained
Parent material	Mudstone
Vegetation	Short grassland
Climate	Tropical highlands; 3 500 mm rainfall

	Profile description	
O	**0-1 cm**	Dark brown organic silt loam; very wet; slightly sticky, slightly plastic; abrupt boundary.
A	**1-12 cm**	Dark brown (10YR 3/3) and dark greyish brown (2.5Y 4/2) silty clay loam, some strong brown rust; wet; firm, plastic, sticky; clear wavy boundary.
Bt1	**12-45 cm**	Yellowish brown (10YR 5/5) clay, many faint distinct fine to medium light olive-brown, strong brown and some reddish brown mottles; wet; firm, plastic, sticky; diffuse boundary.
Bt2	**45-107 cm**	Yellowish brown (10YR 5/6) silty heavy clay, many faint fine light yellowish brown mottles and a few distinct strong brown veins; moist to wet; breaks to angular blocky structure; firm, plastic, slightly sticky; diffuse boundary.
C	**107-180+**	Brownish yellow (10YR 6/6) silty clay, with in places many pink, very pale brown and black patches (black always as a thin coating on crack faces); moist; firm, plastic, slightly sticky, compact; some rock structure visible; some fragments of weathered mudstone.

HUMIC ACRISOL

Papua New Guinea

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	1—12	4.9		29	2.4	8	1.4	0.5	0.2	0.3			
Bt1	12—45	5.0		28	1.1	4	0.7	0.2	0.1	0.1			
Bt2	45—107	5.0		28	1.5	5	0.8	0.2	0.2	0.3			
C	107—180	4.9											

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand *	Silt	Clay **	Texture
A			2.6	0.4	7			1	79	17	3	silt
Bt1			0.9	0.2	5			1	67	13	19	silt loam
Bt2			0.9	0.1	9			1	72	10	17	silt loam
C								1	30	49	20	silt loam

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* Almost entirely in coarse silt (0.02-0.05 µm) range. — ** Low values because of dispersion difficulties.

ORTHIC ACRISOL Ao

Classification	Australia: yellow podzolic soils. Gn 2.74
Reference	Stace *et al.*, 1968. Profile 33B, p. 330. Beerwah Type 2.
Location	Coastal lowlands, Queensland; 26°51'S, 153°01'E
Altitude	15 m
Physiography	A gently sloping ridge crest on low hills marginal to a coastal plain
Drainage	Impeded by clay horizon
Parent material	Quaternary sandy alluvium over Mesozoic sandstone
Vegetation	Cleared from forest
Climate	Humid subtropical; Sh; 1 625 mm rainfall

Profile description

Ah1	**0-15 cm**	Dark brownish grey (10YR 3.5/1.5, 5/1.5 dry) with patches of dark grey (10YR 4/1) and light yellowish brown (1Y 6/4) loamy sand; weakly developed fine subangular blocky round roots grading to massive structure; very friable; dense root material; trace of charcoal.
Ah2	**15-30 cm**	Faintly fine mottled light yellowish brown (1Y 6/4, 7/3 dry), strong brown (7.5YR 3/6) and dark brownish grey clayey sand; massive; very friable; porous; some roots; trace charcoal; diffuse boundary.
AB	**30-40 cm**	Light yellowish brown (1Y 6/4) with diffuse patches of brownish yellow (10YR 6/6) clayey sand; massive; extremely friable; a little quartz sand; a little charcoal; clear boundary.
Bt	**40-75 cm**	Faintly fine mottled yellowish brown (9YR 5-6/6), strong brown (7.5YR 5/6-8) and yellowish red (5YR 4/6) sandy clay loam merging to sandy clay; massive with a few vertical cracks; very friable; few roots mainly along cracks; a few soft 20-mm nodules; a little 10-mm quartz gravel; a little dark red ferruginous sandstone 10-mm gravel; clear boundary.
BC	**75-90 cm**	Distinctly medium mottled yellowish brown (9YR 5-6/6), strong brown (7.5YR 5/8), dark red to red (2.5YR 3-4/6) medium clay; moderately developed very fine blocky structure; peds smooth and dense; firm; few fine roots; few 10-mm nodules; a little 5-mm sandstone and quartz gravel.
C1	**90-120 cm**	Distinctly medium mottled yellowish brown (10YR 5/6), dark red to red (2.5YR 3-4/6) light grey (2.5Y 6.5/2) medium heavy clay; strongly developed very fine blocky structure; peds smooth and dense; firm; few roots; few 10-mm nodules; few sandstone fragments; a little quartz sand and 5-mm gravel; few vertical manganiferous markings.
C2	**120-150 cm**	As above but prominently coarsely mottled pale yellow to yellow (2.5Y 7/5), dark red to red (2.5YR 3-4/6) and light yellowish brown (2.5Y 6/4).

ORTHIC ACRISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									CaCO₃ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—10	5.4		3	2.2	73	1.6	0.2	0.3	0.1			
Ah2	15—20	5.4		3	1.1	37	0.5	0.4	0.1	0.1			
AB	30—40	5.4		2	0.7	35	0.3	0.2	0.1	0.1			
Bt	40—50	5.3		4	1.3	33	0.4	0.7	0.1	0.1			
BC	75—90	4.8		8	1.8	23	0.2	1.4	0.1	0.1			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total		% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.02			0.09		3.2	0	56	35	6	3	loamy sand
Ah2	0.01			0.03		1.3	1	53	33	8	6	loamy sand
AB	0.01			0.01			0	52	30	9	9	clayey sand
Bt	0.01			0.02			1	46	27	7	20	sandy clay loam
BC	0.01			0.01			1	36	14	8	42	clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Avail. P mg %		Free F_2O_3 %	
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5							
Ah1										3		0.31	
Ah2*	96.4	2.0	0.7	0.5	0	0	81	46	66			0.33	
C2	72.0	18.9	6.1	0.7	0	0	7	32	5				

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* 20-30 cm.

CHROMIC CAMBISOL Bc

Classification	Solomon Islands: Nakeo Land System, Eutropepts
Reference	Land Resources Division, ODA. Profile Guadalcanal 139
Location	Kopiu bay area; 9°43′S, 160°44′E
Altitude	150 m
Physiography	Upper slope, broad topped hill, 20-degree slope
Drainage	Well drained
Parent material	Quaternary sedimentary rocks, conglomerates, sandstones, limestone
Vegetation	Primary or very old secondary forest
Climate	Semihot equatorial; 2 500 mm rainfall

Profile description

Ah1	**0-1 cm**	Very dark greyish brown (10YR 3/2) silt loam; weakly developed very fine crumb structure; very friable; abrupt wavy boundary.
Ah2	**1-23 cm**	Yellowish red (5YR 4/8) clay loam to clay; massive to moderately developed very fine angular blocky structure; friable; common interstitial pores; common fine fibrous and woody roots; few 1-cm soft red sandstone pebbles; gradual wavy boundary.
Bw1	**23-56 cm**	Yellowish red (5YR 4/8) clay loam; massive to moderately developed very fine angular blocky structure; friable; common pores; few roots; common 1-cm red pebbles; gradual smooth boundary.
Bw2	**56-107 cm**	Red (2.5YR 4/6) clay loam; massive to weakly developed very fine subangular blocky structure; very friable; few pores; few roots; common 1-cm red and some black pebbles; gradual smooth boundary.
BC	**107-137+**	Red (2.5YR 4/6) gritty clay loam to gritty clay; common coarse faint distinct yellowish red and strong brown mottles; massive to weakly developed very fine subangular blocky structure; very friable; many intergranular pores; rare roots.

CHROMIC CAMBISOL

Solomon Islands

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	1—23	5.2		13.0	1.0	8	0.4	0.5	0.1	0			
Bw1	23—56	5.1		15.2	1.5	9	1.2	0.2	tr	0.1			
Bw2	56—107	5.1		18.0	0.7	4	0.4	0.2	tr	0.1			
BC	107—137	5.2		21.2	1.0	5	0.4	0.4	tr	0.1			

Horizon	Sol. salts		Organic matter %				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			3.2	0.28	11			4	8	19	69	clay
Bw1			1.2	0.12	10			2	8	27	63	clay
Bw2								3	13	36	48	silty clay
BC								4	16	35	45	silty clay

Horizon	Phosphorus mg %					Total %				Bulk density			
	Total	$\frac{NH_4F}{HCl}$				K	Mg						
A	30	0.3				0.06	0.19			0.77			
Bw1	35	1.0				0.07	0.28			0.67			
Bw2	35	0.8				0.08	0.35			0.66			
BC	33	0.9				0.10	0.41			0.64			

DYSTRIC CAMBISOL Bd

Classification	New Zealand: strongly leached yellow-brown earth
Reference	New Zealand Soil Bureau, 1968, p. 46-47. Waikiwi silt loam
Location	Near Invercargill, Southland; 46°22′S, 168°41′E
Altitude	65 m
Physiography	Smooth convex 3-degree slope to south
Drainage	Moderately well drained
Parent material	Loess from tuffaceous greywacke and schist overlying, at 170 cm, weathered gravels
Vegetation	Tall tussock, previously was probably podocarp-dicotylous forest
Climate	Humid mild patagonian marine; 1 100 mm rainfall

Profile description

Ah	**0-20 cm**	Dark greyish brown (10YR 4/2) silt loam; moderately developed medium and fine subangular blocky structure; friable to firm; many grass roots; diffuse wavy boundary.
AB	**20-28 cm**	Silt loam; worm-mixed horizon; moderately developed medium and fine subangular blocky structure; friable; some grass roots; clear boundary.
Bw	**28-43 cm**	Yellowish brown (10YR 5/6) silt loam; very weakly developed coarse breaking to fine blocky structure; friable to firm, stickier than above; few roots; few small very dark brown soft iron-manganese nodules; diffuse boundary.
BC	**43-51 cm**	Pale brownish grey (10YR-2.5Y 6/2) silt loam; reddish yellow (7.5YR 6/8) and yellowish red (5YR 5/8) stains on some ped faces; very weakly developed very fine to fine blocky structure; firm; diffuse boundary.
C	**51+**	Yellowish brown (10YR 5/6) silt loam; red (2.5YR 5/8) stains on some ped faces; very weakly developed fine blocky structure; friable to firm; some dark brown soft nodules.

DYSTRIC CAMBISOL

New Zealand

Horizon	Depth cm	pH		Cation exchange me %									CaCO₃ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—8	5.5	4.3	17.7	4.9	28	3.3	1.3	0.6	0.2			
Ah2	10—18	5.8	4.4	14.4	2.9	20	2.0	0.7	0.2	0.2			
Bw	28—43	5.7	4.5	8.5	0.2	2	0.4	0	0.1	0.1			
BC	43—51	5.7	4.5	7.7	0 1	1	0.4	0.1	0.2	0.1			
C	51—66	5.7	4.4	7.6	0.3	4	0.5	0.2	0.2	0.1			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			6.6	0.39	17			31		41	28	silt loam
Ah2			4.1	0.29	14			40		31	29	silt loam
Bw			1.4	0.13	11			39		43	18	silt loam
BC			0.5	0.05	10			40		41	19	silt loam
C			0.4	0.05	8			37		41	22	silt loam

Horizon	Phosphorus mg %						Tamm's oxalate %			Bulk density	Field capacity	Wilting point	
	Total	Org.	Truog	NH_2SO_4	P retention		Al	Fe					
Ah1	80	56	0.5	10	57		0.57	0.78		1.01	49	24	
Ah2													
Bw	47	31	0.2	6	72		0.71	0.87		1.21	34	22	
BC	42	21	0.2	11	62		0.63	0.80		1.36	29	21	
C	43	21	0.5	10	57		0.38	0.75			30	21	

EUTRIC CAMBISOL Be

Classification	New Hebrides: sol brun eutrophe tropical, peu évolué (montmorillonitic phase)
Reference	New Hebrides, 261
Location	Maewo, E.; Olbanga; 15°8′S, 168°8′E
Altitude	250 m
Physiography	Steep and very dissected slopes, on high cliff
Drainage	Very well drained
Parent material	Pliocene basaltic lavas
Vegetation	Low rain forest
Climate	Semihot equatorial; > 3 000 mm rainfall

Profile description

A	**0-20 cm**	Very dark grey brown, almost black (7.5YR 3/1) silty clay; medium to large crumb to granular structure; strong cohesion; very porous and permeable; very abundant roots.
BA	**20-40 cm**	Dark brown (7.5YR 3/2) silty clay; fine blocky structure; strong cohesion; porous and permeable; abundant roots.
Bw	**40-60 cm**	Dark brown (7.5YR 4/2) silty clay; fine blocky structure; strong cohesion; permeable; fairly abundant roots.
BC	**60-120 cm**	Brown (7.5YR 4/3) sandy loam with some gravels or pebbles from weathered basalt; massive and platy structure; friable; fine porosity; few roots.

EUTRIC CAMBISOL

New Hebrides

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—20	6.4		79.2	77.7	98	57.4	14.2	5.1	0.9			
Bw	40—50	5.5		78.8	72.1	92	48.4	19.7	3.2	0.8			
BC	80—120	6.2		85.0	74.2	87	56.2	10.3	5.9	1.8			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			3.9	0.31	11	6.5		6	28	35	31	clay loam
Bw			0.8	0.07	12	1.6		13	38	26	23	loam
BC			0.27	0.026	10	0.6		32	33	16	19	sandy loam

Horizon	Solution by HClO$_4$ %										H$_2$O % retention		
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO$_2$	P$_2$O$_5$	Loss on ign.	Resid.			pF0.3	pF4.2	
A	35.3	13.3	11.1	0.97	0.27	0.10	28.4	2.6			78.9	57.1	
Bw	36.6	15.4	11.6	0.79	0.29	0.05	25.4	2.3			64.0	52.5	
BC	38.5	14.5	10.8	0.65	0.23	0.01	24.1	1.4			48.7	40.6	

Horizon	Solution by HClO$_4$ me %				Mol. ratios		Avail. P truog mg %						
	Ca	Mg	K	Na	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{R_2O_3}$							
A	65	270	9.5	2.9	4.5	2.9	0.7						
Bw	52	283	6.6	2.6	4.1	2.7	0.1						
BC	71	313	5.9	5.8	4.5	2.9	0.1						

FERRALIC CAMBISOL Bf

Classification	Western Samoa: strongly leached humic latosol transitional to hydrol humic latosol
Reference	Wright, 1963, p. 67, 79, 164. Tuave clay
Location	Upper foothills, northeast Upolo
Altitude	150 m
Physiography	Plateau remnants and broad ridge tops on rolling terrain, 5-degree slope
Drainage	Moderately well drained
Parent material	Basic andesites, basalts
Vegetation	Very open second-growth forest
Climate	Humid equatorial; *ca.* 3 000 mm rainfall

Profile description

A	**0-8 cm**	Dark brown (7.5YR 3/2) clay; moderately developed coarse and medium blocky breaking to fine blocky and coarse granular structure; friable, slightly sticky, slightly to moderately plastic; diffuse boundary.
BA	**8-30 cm**	Dark brown to brown (7.5YR 4/2) clay; weakly developed coarse and medium blocky breaking to coarse granular and crumb structure; friable, slightly sticky, slightly plastic; diffuse boundary.
Bws	**30-70 cm**	Dark brown (7.5YR 3/2) slightly stony clay; massive breaking to very strongly developed medium granular structure; friable, very slightly sticky, moderately plastic; diffuse boundary.
C	70+	Dark greyish brown very stony clay; rock fragments subangular and well weathered.

FERRALIC CAMBISOL

Western Samoa

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—8	4.4		15.7	3.5	22	2.0	1.2	0.2	0.1			
BA	8—30	5.3		4.8	0.6	13	0.3	0.1	0.1	0.1			
Bws	30—50	5.6		2.3	0.3	13	0.2	0	0.1	0			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			2.9	0.20	15							
BA			5.3	0.48	11							
Bws			2.2	0.09	24							

Horizon										P			
A										4			
BA										1			
Bws										1			

HUMIC CAMBISOL Bh

Classification	Australia: alpine humus soils. Um 7.11
Reference	Stace *et al.*, 1968. Profile 40c, p. 391
Location	Monaro region, New South Wales; 36°24'S, 148°27'E
Altitude	1 740 m
Physiography	On lower gentle slopes of a glacial column
Drainage	Well drained
Parent material	Gneissic granite
Vegetation	Open subalpine woodland
Climate	Humid patagonian; A; 1 250 mm rainfall

Profile description

Ah1	**0-15 cm**	Black (10YR 2/1) peaty loam; granular; soft; fibrous mass of brown roots; diffuse boundary.
Ah2	**15-46 cm**	Black (10YR 2/1) peaty loam; granular; soft; diffuse boundary.
Ah3	**46-61 cm**	Very dark brown (10YR 2/2) peaty loam; very weakly developed granular structure; soft; diffuse boundary.
AB	**61-76 cm**	Very dark greyish brown (10YR 3/2) loam; very weakly developed granular structure; powdery; some weathered rock; diffuse boundary.
Bw	**76-91 cm**	Dark yellowish brown (10YR 3/5) loam; weakly developed subangular blocky structure; powdery; some weathered rock; diffuse boundary.
C	**91-107 cm**	Speckled dark brown and near white weathered gneissic granite.

HUMIC CAMBISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—15	5.1		27	12.5	46	8.5	2.7	1.2	0.1			
Ah2	15—30	5.3											
Ah3	46—61	5.3		16	1.9	12	1.1	0.4	0.2	0.2			
Bw	76—91	5.4		13	0.9	7	0.5	0.2	0.1	0.1			
C	91—107	5.4											

Horizon	Sol. salts %		Organic matter				Particle size analysis* %					
	Total		% C	% N	C/N	Ignition loss %	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.03			0.97		30	8	25	21	19	35	peaty loam
Ah2	0.02			0.81		23	9	25	21	20	34	peaty loam
Ah3	0.01			0.45		17	5	29	23	28	20	peaty loam
Bw	0.01			0.17		10	4	36	30	17	17	loam
C	0.01					8	4	48	31	11	10	sandy loam

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5						
Ah1	70.2	17.4	7.8	1.0	0.24	0.34	7	24	5			
Bw	64.5	20.6	7.3	0.9	0.14	0.19	5	24	4			

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* Calculated on organic matter-free soil < 2 mm. Note high levels of organic matter.

CALCIC CAMBISOL Bk

Classification	Fiji: latosolic soils
Reference	Twyford and Wright, 1965, p. 547. Cikobia rocky red clay
Location	Na Bavatu Estate, Vanua Balavu; 17°12'S, 178°58'W
Altitude	50 m
Physiography	Flattish, 3 degrees, limestone plateau
Drainage	Very well drained
Parent material	Coral limestone with volcanic ash or ocean bottom muds
Vegetation	Calcicole heavy forest; now coconuts, weeds
Climate	Equatorial; *ca.* 2 000 mm rainfall

Profile description

A	**0-15 cm**	Dark reddish brown to reddish brown (2.5YR 3/4-4/4) clay, slightly stony (limestone); strongly developed medium and fine blocky and subangular blocky breaking to very strongly developed very fine subangular blocky and " breadcrumb " structure; very friable, slightly sticky, moderately plastic; clear boundary.
Bwk	**15-75+**	Red (2.5YR 4/8) clay; weakly developed medium blocky breaking to fine subangular blocky " breadcrumb " and single-grain structure; very friable, sticky, very plastic, very compact.

CALCIC CAMBISOL

Fiji

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—25	7.2		26.9	32.6	100	27.1	5.2	0.3				
								(slightly calcareous)					

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			4.5	0.19	24							

Horizon										Acid-soluble P			
A										11			

RENDZINA	E
Classification	Papua New Guinea: Rendzinas
Reference	Haantjens *et al.*, 1967, p. 56. Profile WLS-P20
Location	Northwest New Guinea; 3°47′S, 143°36′E
Altitude	250 m
Physiography	Steep slope (30°) close to rounded crest of limestone hill
Drainage	Well drained
Parent material	Limestone
Vegetation	Lowland hill forest
Climate	Humid semihot equatorial; 1 500-2 500 mm rainfall

	Profile description	
A	**0-30 cm**	Almost black (5YR 2/1 dry) clay loam; moderately developed fine subangular blocky structure; hard; white speckles of limestone; abrupt irregular boundary.
C	**30-50 cm**	Yellowish white limestone or limestone grit; powdery; usually compact; locally fractured, with black soil in the voids.

RENDZINA

Papua New Guinea

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—30	7.7		55	free	$CaCO_3$		3.1	0.5	0.8			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			3.7	0.5	7			19	13	52	16	silt loam

ACRIC FERRALSOL Fa

Classification	New Caledonia: Sol ferrallitique ferritique
Reference	ORSTOM, 1970. Profile JOU 1
Location	Ouenarou; 22°09'S, 166°42'E
Altitude	150 m
Physiography	Slope of 11 degrees in hilly terrain
Drainage	Well drained
Parent material	Ultrabasic rocks, weakly serpentinized peridotite
Vegetation	Scrub
Climate	Humid tropical; 2 300 mm rainfall

Profile description

A	**0-27 cm**	Dark reddish brown (2.5YR 3/4) clay, slightly gravelly; moderately developed medium to fine crumb structure; loose; many fine and medium interstitial pores; many medium and fine roots; few small hard irregular ferruginous nodules; clear smooth boundary.
BA	**27-43 cm**	Reddish brown clay loam, slightly gravelly; weakly developed medium to fine subangular blocky structure; loose; many fine and medium interstitial pores; many fine and medium roots; few small hard irregular ferruginous nodules; clear smooth boundary.
Bws	**43-85 cm**	Dark red (2.5YR 3/6) clay loam, slightly gravelly; massive to angular structure; not sticky, slightly plastic; few fine vesicular pores; very few fine roots; few small ferruginous nodules; gradual smooth boundary.
BC	**85-150 cm**	Reddish brown (5YR 4/4) stony sandy loam, few fine distinct black net mottles; weakly developed subangular blocky structure; slightly sticky, slightly plastic; few fine pores; very few roots; few rounded peridotite fragments; clear irregular boundary.
R	**150+**	Unweathered rock surrounded with a coating, still hard, up to 1 cm thick, containing numerous pyroxenes.

ACRIC FERRALSOL

New Caledonia

Horizon	Depth cm	pH		Cation exchange me %								$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na		
A	0—20	5.3		5.8	3.0	51	1.0	1.8	0.1	0.1		
Bws	60—80	5.8		1.3	0.5	36	0.2	0.2	0	0.1		
BC	130—140	6.7		8.1	1.1	13	0.2	0.9	0	0		

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			2.7	0.12	22			8	11	33	48	clay
Bws			0 3	0.04	7			5	23	33	39	clay loam
BC			0.2	0.02	10			15	12	38	35	clay loam

Horizon	Solution by $HNO_3 + HClO_4$ %												
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO_2	NiO	Cr_2O_3	P_2O_5					
A	3.1	8.7	59.0	0.2	0.3	0.8	3.3	0.04					
Bws	2.1	8.7	64.3	0.2	0.2	1.1	2.8	0.04					
BC	4.6	5.2	50.0	0.1	0.5	1.6	4.1	0.02					

Horizon	Solution by $HNO_3 + HCLO_4$ me %												
	Ca	Mg	K	Na									
A	1.0	16.9	0.1	3.2									
Bws	1.1	11.9	0	4.2									
BC	0.4	58.0	0	2.9									

HUMIC FERRALSOL Fh

Classification	Hawaii: Tropeptic Umbriorthox
Reference	Foote *et al.*, 1972, p. 80-81, 220-221. Lawai silty clay
Location	Kanai Island; 21°57'26"N, 159°27'36"W
Altitude	150-250 m
Physiography	Colluvial slopes, alluvial fans and stream bottoms, 0- to 5-degree slopes
Drainage	Moderate to well drained
Parent material	Alluvium and colluvium
Vegetation	Grasses, shrubs and trees
Climate	Semihot tropical; 2 000-4 000 mm rainfall

Profile description

Ap	**0-15 cm**	Very dark greyish brown (10YR 3/2) silty clay; weakly developed fine and very fine subangular blocky structure; very hard, friable, sticky, plastic; many interstitial and tubular pores; abundant roots; clear broken boundary.
A/B	**15-35 cm**	Dark brown (7.5YR 4/4, 3/2 dry) silty clay; weakly developed very fine subangular blocky structure; very hard, firm, sticky, plastic; many pores; abundant roots; nearly continuous pressure cutans; considerable mixing with Ap horizon by cultivation; clear wavy boundary.
Bws1	**35-66 cm**	Dark brown (7.5YR 4/4, 3/2 dry) silty clay; weakly developed fine and very fine subangular blocky structure; very hard, firm, sticky, plastic; many pores; abundant roots; weak pressure cutans; gradual smooth boundary.
Bws2	**66-107 cm**	Dark brown (7.5Y 3/4, 3/2 dry) silty clay; moderately developed coarse angular blocky breaking to very fine and fine subangular blocky structure; very hard, firm, sticky, plastic; very few roots; nearly continuous pressure cutans; gradual smooth boundary.
Bws3	**107-134 cm**	Dark brown (7.5YR 3/3) silty clay, coatings in pores have a higher chroma; moderately developed fine and very fine angular and subangular blocky structure; very hard, firm, sticky, plastic; common pores; continuous pressure cutans; about 5 percent weathered rock; gradual smooth boundary.
Bws4	**134-152 cm**	Dark brown (7.5YR 3/4, 4/2 dry) silty clay; coarse to very fine angular and subangular blocky structure; hard, firm, sticky, plastic; few pores; continuous pressure cutans.

HUMIC FERRALSOL

Hawaii

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ap	0—28	4.3	3.8	15.6	0.8	5	0	0.6	0.1	0.1			
Bws1	28—56	4.8	4.1	13.7	1.2	9	0	1.0	0.1	0.1			
Bws2	56—100	4.9	4.1	15.9	2.5	16	0.8	1.4	0.1	0.2			
Bws3	100—147	4.9	3.9	15.6	2.7	17	0.8	1.4	0.1	0.4			
Bws4	147—162	4.8	3.8	14.1	2.6	18	0.7	1.1	0.1	0.7			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ap			3.0	0.24	12							
Bws1			1.9	0.17	11							
Bws2			1.2	0.11	11							
Bws3			0.8	0.08	10							
Bws4			0.6	0.05	12							

Horizon	Total analysis %									Bulk density	Moisture retention		
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO	P$_2$O$_5$	Loss on ign.				1/3 atm	15 atm	
Ap	18.3	22.5	28.9	7.9	0.07	0.29	15.4			0.94	50	36	
Bws1	17.3	25.0	28.8	5.6	0.09	0.26	16.1			0.93	64	49	
Bws2	18.2	26.4	27.8	4.3	0.10	0.26	15.5			0.91	65	51	
Bws3	20.9	25.4	26.4	3.8	0.07	0.23	15.1			0.93	68	52	
Bws4											55	40	

Horizon	Total analysis %									Free Fe$_2$O$_3$ %			
	CaO	MgO	K$_2$O	Na$_2$O									
Ap	0	0.74	0.99	0.07						20.4			
Bws1	0.06	0.62	0.78	0.07						24.2			
Bws2	0	0.60	0.47	0.04						24.2			
Bws3	Tr.	0.58	0.28	0.04						26.3			
Bws4										22.2			

ORTHIC FERRALSOL Fo

Classification	Solomon Islands: Dala Land System, Haplorthox
Reference	Land Resources Division, ODA. Profile Malaita 58
Location	South Ulawa; 9°50'2, 161°58'E
Altitude	9-18 m
Physiography	Smooth terrace surface, slope 0-2%
Drainage	Well drained
Parent material	Coral limestone
Vegetation	Primary forest, 30-40 m high
Climate	Semihot equatorial; 3 000-4 000 mm rainfall

Profile description

Ah1	**0-5 cm**	Dark brown (7.5YR 3/2) loam; very friable.
Ah2	**5-38 cm**	Brown to dark brown (7.5YR 3-4/4) clay loam; very friable to friable.
Bws1	**38-76 cm**	Brown to dark brown (7.5YR 3-4/4) clay loam; very friable to friable.
Bws2	**76-122+**	Brown to dark brown (7.5YR 4/4) clay loam or loam, with common faint diffuse dark brown mottles; friable, nonsticky, slightly plastic; fragments of coral.

ORTHIC FERRALSOL
Solomon Islands

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—5	6.6		33.7	26.4	79	22.9	2.8	0.3	0.4			3.0
Ah2	5—38	6.4		14.5	9.7	67	7.8	1.6	0.1	0.2			2.5
Bws1	38—76	6.2		6.7	4.3	64	3.2	1.0	tr	0.1			2.0
Bws2	76—122	6.7		6.8	8.0	100	7.0	0.9	tr	0.1			3.0

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			7.0	0.84	8			8	14	27	51	clay
Ah2			2.7	0.38	7			0	0	34	66	clay
Bws1			0.9	0.14	6			0	0	32	69	clay
Bws2			0.6	0.11	5			0	7	27	66	clay

Horizon	Phosphorus mg %					Total %				Bulk density		
	Total	Olsen	$\frac{NH_4F}{HCl}$			K	Mg					
Ah1	598	0.4	0.7			0.10	0.31			0.71		
Ah2	548	0.6	1.0			0.10	0.33			0.74		
Bws1	571	2.2	1.5			0.10	0.23			0.69		
Bws2	545	2.1	1.4			0.11	0.32			0.69		

RHODIC FERRALSOL Fr

Classification	Hawaii: Tropeptic Eutrustox
Reference	Foote *et al.*, 1972, p. 82-83, 220-221. Lihue silty clay
Location	Kanai Island; 21°59'07"N, 159°21'50"W
Altitude	Up to 250 m
Physiography	Broad interfluves in uplands, 0- to 5-degree slopes
Drainage	Well drained
Parent material	Basic igneous rock
Vegetation	Grasses, shrubs and trees
Climate	Semihot tropical; 1 000-1 500 mm rainfall

Profile description

Ap	**0-30 cm**	Dusky red (2.5YR 3/2, 5YR 4/8 dry) silty clay; massive, breaking to weakly developed fine and medium subangular blocky structure in top 15 cm; very hard, firm to friable, sticky, plastic; common very fine and fine pores; abundant roots; many black concretions; abrupt smooth boundary.
Bws1	**30-53 cm**	Dark reddish brown (2.5YR 3/4, 4/6 dry) silty clay; moderately developed medium to very fine subangular blocky structure; many very fine and fine pores; abundant roots; many fine black concretions; nearly continuous glaze on ped faces; glaze looks like clay films; clear broken boundary.
Bws2	**53-69 cm**	Dard reddish brown (2.5YR 3/4, 4/6 dry) silty clay; strongly developed very fine subangular blocky structure; very hard, friable, sticky, plastic; many pores; many roots; common black concretions; glaze on ped faces: few fine black manganese dioxide stains on ped faces; clear smooth boundary.
Bws3	**69-122 cm**	Dark redidsh brown (2.5YR 3/4, 4/6 dry) silty clay; strongly developed very fine subangular and angular blocky structure; hard, firm, sticky, plastic; many pores; few roots; glaze on ped faces looks like thick clay films; black coatings on primary structural units; gradual smooth boundary.
Bws4	**122-150 cm**	Dark red (2.5YR 3/6, 4/6 dry) silty clay; hard, firm, slightly sticky, plastic; many pores; no roots; thin patchy coatings, many distinct pressure cutans.

RHODIC FERRALSOL

Hawaii

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ap1	0—15	5.5	5.0	19.1	12.2	64	6.8	4.4	0.8	0.2			
Ap2	15—30	5.5	4.9	17.3	9.0	52	5.3	3.3	0.3	0.1			
Bws1	30—53	6.3	6.0	7.9	5.3	67	3.0	1.9	0.2	0.2			
Bws2	53—69	6.6	6.2	7.3	4.4	60	2.7	1.5	0.1	0.1			
Bws3	69—122	6.6	6.2	7.4	4.5	61	3.0	1.2	0.1	0.2			
Bws4	122—150	6.6	6.2	8.3	5.8	70	3.6	1.7	0.1	0.4			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ap1			2.7	0.27	10							
Ap2			2.0	0.21	10							
Bws1			0.5	0.09	6							
Bws2			0.4									
Bws3			0.4									
Bws4			0.4									

Horizon	Total analysis %								Bulk density		Moisture retention	
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO	P$_2$O$_5$	Loss on ign.				1/3 atm	15 atm
Ap1	21.1	28.5	20.8	4.2	1.2	0.56	17.0		0.96		46	34
Ap2	20.8	29.7	19.9	4.0	1.4	0.60	16.3		1.03		46	34
Bws1	23.8	30.7	21.8	4.4	0.5	0.32	13.5		1.13		30	32
Bws2	22.8	29.1	22.9	4.8	0.2	0.37	13.2		1.21		38	33
Bws3	24.2	28.0	24.0	5.4	0.2	0.37	12.5		1.21		40	34
Bws4	23.1	27.2	25.5	5.8	0.1	0.40	12.4		1.19		40	35

Horizon	Total analysis %								Free Fe$_2$O$_3$ %		
	CaO	MgO	K$_2$O	Na$_2$O							
Ap1	0.08	0.95	1.11	0.18					18.6		
Ap2	tr	1.04	1.11	0.16					18.4		
Bws1	tr	0.56	1.09	0.21					20.6		
Bws2	tr	0.62	1.08	0.19					21.2		
Bws3	tr	0.45	0.78	0.18					22.6		
Bws4	tr	0.07	0.51	0.15					23.2		

HUMIC GLEYSOL Gh

Classification	Australia: humic gleys. Uf 6.42
Reference	Stace *et al.*, 1968. Profile 41B, p. 397. Burnett Type 2.
Location	Bundaberg district, Queensland; 24°46′S, 152°21′E
Altitude	8 m
Physiography	Coastal plain with relief of about 1.5 m
Drainage	Poorly drained
Parent material	Quaternary marine and river muds
Vegetation	Cleared, probably from coastal savanna woodland to grassy forest
Climate	Semihot semitropical; Sm; 1 070 mm rainfall

Profile description

A	**0-20 cm**	Very dark greyish brown to very dark grey (10YR 3/1.5, 5/2 dry) silty clay loam; cloddy (8 cm); hard, friable; porous; fine quartz sand grains on surface and in top 3 cm; clear boundary.
AB	**20-30 cm**	Very dark grey to dark grey (10YR 3.5/1), with few dark brown (9YR 3/3) patches, silty clay; moderately developed coarse blocky structure; firm; slightly porous; few roots; diffuse boundary.
Bg1	**30-78 cm**	Very dark grey to very dark greyish brown (10YR 3/1.5) silty clay with fine distinct strong brown (7.5YR 5/6) and dark yellowish brown (10YR 4/4) mottles; moderately developed coarse prismatic breaking to coarse blocky structure; very firm, plastic; slightly porous; few roots; diffuse boundary.
Bg2	**78-110 cm**	Very dark grey (10YR 3/1) silty clay with medium prominent grey (2.5Y 5/1-6/1) and yellowish brown (9YR 5/6) mottles; few black segregations; reddish brown ferruginous deposit along root lines; diffuse boundary.
BCr	**110-138 cm**	Grey (2.5Y 5/1-6/1) silty clay with coarse distinct very dark grey (10YR 3/1, 4/0) mottles and fine brown and brownish yellow flecks; weakly developed very coarse prismatic breaking to coarse blocky structure; firm, very plastic; few black segregations; few ferruginous tubes and channels; diffuse boundary.
Cr1	**138-160 cm**	Dark grey to dark greyish brown (2.5Y 4/1) light clay, fine sandy clay deeper, with fine distinct brownish red (2.5YR 3/3-4/4) and yellowish brown (10YR 5/8-6/8) mottles; weakly developed very coarse prismatic breaking to coarse blocky structure; plastic; few black segregations; few ferruginous tubules; diffuse boundary.
Cr2	**160-200 cm**	Grey (N 4/0) clay loam with fine distinct reddish brown (5YR 4/4) and dark reddish brown (2.5YR 3/4) mottles; massive with few fracture planes; sticky; few pockets of very light grey sand; diffuse boundary.
Cr3	**200+**	Laminated sedimentary deposits of grey clay loam and light brownish grey sand.

HUMIC GLEYSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	6.0		24	18.6	78	10.0	5.9	0.5	2.2			
AB	20—30	5.4		14	13.0	93	6.3	4.5	0.2	2.0			
Bgl	60—78	5.4		23	20.2	88	7.0	10.0	0.2	3.0			
BCr	110—120	5.1		21	16.9	81	4.4	10.0	0.3	2.2			
Crl	138—150	4.8		15	13.2	88	3.5	7.9	0.2	1.6			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.13	0.10		0.13		3.0		0	26	34	40	silty clay loam
AB	0.17	0.10		0.12		2.9		0	22	35	43	silty clay
Bgl	0.24	0.14		0.09		1.7		0	24	28	48	silty clay
BCr	0.21	0.10		0.02				0	38	24	38	silty clay
Crl	0.21	0.09		0.01				2	50	17	31	light clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$				
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO_2	P_2O_5							
AB	69.3	17.0	6.6	1.3	0.09	0.15	6.9	28	5.5				
Bgl	71.0	17.2	4.6	1.3	0.03	0.05	7.0	41	6.0				

GLEYIC PHAEOZEM Hg

Classification	Papua New Guinea: alluvial soils
Reference	Haantjens (pers. comm.). Profile LRA-P14
Location	Near Annanberg; 4°55′S, 144°40′E
Altitude	40 m
Physiography	Alluvial plain
Drainage	Poorly drained
Parent material	Old alluvium
Vegetation	Palm forest
Climate	Humid semihot equatorial; 2 500-3 500 mm rainfall

Profile description

Ah1	**0-15 cm**	Dark brown (10YR 3/3) heavy clay; few small brown mottles; firm to very firm; abrupt boundary.
Ah2	**15-30 cm**	Very dark grey (10YR 3/1) heavy clay; few to common small dark brown mottles; very firm, very plastic; clear boundary.
Br1	**30-60 cm**	Grey (N 5/0) heavy clay; common medium yellowish brown to brown mottles; very firm, very plastic; clear boundary.
Br2	**60-94 cm**	Greyish brown (10YR 5/2) clay to heavy clay; many small strong brown mottles; firm, plastic; clear boundary.
Cr	**94-104 cm**	Very light grey heavy clay; very firm, very plastic; clear boundary.
Ab	**104-117 cm**	Black (10YR 2/1) heavy clay; very firm, very plastic; buried A horizon; clear boundary.
Brb	**117-122 cm**	Light brownish grey (2.5Y 6/2) and grey (5Y 6/1) heavy clay; common small yellowish brown mottles; very firm, very plastic.

GLEYIC PHAEOZEM

Papua New Guinea

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—15	6.4		52.6	30.7	58	16.8	13.2	0.4	0.3			
Br1	30—60	7.2		60.5	36.7	60	18.0	18.0	0.2	0.5			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			1.4	0.40	4			0	2	62	36	silty clay loam
Br1			0.3	0.13				0	1	65	34	silty clay loam

HAPLIC PHAEOZEM Hh

Classification	Hawaii: Torroxic Haplustoll
Reference	Foote *et al.*, 1972, p. 65-67, 220-221. Keahua silty clay loam
Location	Maui Island; 20°49′56″N, 156°23′08″W
Altitude	200-450 m
Physiography	Uplands, 2- to 4-degree slopes
Drainage	Moderately well drained
Parent material	Soft weathered basic igneous rock
Vegetation	Grasses, shrubs, trees
Climate	Semihot tropical; 400-650 mm rainfall

Profile description

Ap	**0-25 cm**	Dark reddish brown (5YR 3/2-3, 3/3-4 dry) silty clay loam; weakly developed very fine granular and very fine and fine subangular blocky structure grading to medium and coarse subangular blocky in the lower part of the horizon; common clods up to 5 cm; soft, friable, slightly sticky and plastic; many very fine pores; abundant roots; common hard sand-sized aggregates and fine black concretions; clear wavy boundary.
BA	**25-38 cm**	Dark reddish brown (5YR 3/3, 3/4 dry) silty clay loam; weakly developed coarse and medium subangular blocky structure; soft, very friable, slightly sticky and plastic; many fine pores; abundant roots; few aggregates and concretions; gradual wavy boundary.
Bw	**38-84 cm**	Dark reddish brown (5YR 3/3, 3/4 dry) silty clay loam; moderately developed medium to very fine subangular blocky structure; slightly hard, friable to firm, slightly sticky and plastic; many to common fine and medium pores; few roots; firm in place; few aggregates and concretions; clear wavy boundary.
2BC, 2C	**84-178 cm**	Very dark grey (10YR 3/1, 4/1 dry) clay loam; moderately developed fine and very fine subangular blocky structure; hard, firm, slightly sticky and plastic; common fine pores; few roots; nearly continuous pressure cutans; firm in place; many hard sand-sized aggregates; contains 60 to 70 percent highly weathered rock fragments in bottom 20 cm.

HAPLIC PHAEOZEM

Hawaii

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na	Al		
Ap1	0—13	5.6	4.7	15.6	9.5	61	6.2	2.6	0.5	0.2	0.1		
Ap2	13—25	5.7	4.8	14.3	9.5	66	6.4	2.7	0.2	0.2	0		
BA	25—38	6.3	5.4	10.2	7.0	69	5.1	1.8	tr	0.1			
Bw	38—61	6.4	5.6	8.8	6.1	69	4.2	1.7	tr	0.2			
2BC	84—122	6.7	5.5	14.4	9.9	69	5.1	2.8	tr	2.0			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ap1			1.1	0.14	8							
Ap2			1.1	0.13	8							
BA			0.6	0.09	6							
Bw			0.5	0.08	6							
2BC			0.2									

Horizon	Total analysis %									Bulk density	Free Fe_2O_3 %	Moisture retention	
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5	Loss on ign.					1/3 atm	15 atm
Ap1	28.3	27.9	20.2	5.1	0.47	0.41	11.6			1.12	12.3	27	22
Ap2	28.8	28.0	20.2	5.1	0.49	0.44	11.9			1.14	13.9	26	22
BA	28.0	28.8	20.9	5.0	0.45	0.27	11.1			1.23	14.2	28	22
Bw	27.7	29.0	20.9	5.2	0.36	0.41	11.0			1.27	13.9	29	22
2BC	29.2	24.3	20.7	6.4	0.28	0.19	10.4			1.32	9.0	29	25

Horizon	Total analysis %												
	CaO	MgO	K_2O	Na_2O									
Ap1	0.02	1.15	0.35	0.18									
Ap2	0.03	0.95	0.30	0.16									
BA	0.03	1.14	0.29	0.16									
Bw	0.02	1.09	0.28	0.17									
2BC	0.02	1.06	0.05	0.15									

EUTRIC FLUVISOL Je

Classification	New Caledonia: Sol peu évolué d'apport fluviatile
Reference	ORSTOM, 1971. Profile FOA4
Location	Foa, Thio road; 21°55'S, 166°24'E
Altitude	10 m
Physiography	Flat plain
Drainage	Moderately well drained
Parent material	Alluvium
Vegetation	Abandoned coffee plantation
Climate	Humid tropical; 1 200 mm rainfall

Profile description

A	**0-8 cm**	Dark brown (10YR 3/3) silty clay; moderately developed fine subangular blocky to granular structure; friable, sticky, plastic; many interstitial pores; many medium and fine roots; clear smooth boundary.
AC	**8-45 cm**	Dark greyish brown (10YR 4/2) silty clay; moderately developed medium subangular blocky structure; firm; common fine tubular pores; many medium and fine roots; gradual smooth boundary.
C1	**45-100 cm**	Dark greyish brown (10YR 4/2) silty clay; weakly developed large prismatic structure; very firm; many fine tubular pores; few medium and fine roots; gradual smooth boundary.
C2	**100-140 cm**	Brown to dark brown (10YR 4/3) silty clay with common medium faint clear mottles; weakly developed medium angular blocky to medium prismatic structure; very firm; many fine tubular pores; few fine roots.

EUTRIC FLUVISOL

New Caledonia

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—8	5.5		34.9	37.9	100	17.3	16.8	0.5	0.2			
AC	20—30	6.4		25.2	31.1	100	11.4	19.5	0.1	0.1			
C2	120—130	6.5		21.5	30.7	100	4.2	24.9	0.1	1.5			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			11.2	0.70	16			0	5	46	49	clay
AC			1.5	0.19	8			0	8	46	46	clay
C2			0.6	0.08	8			1	5	49	45	clay

Horizon	Solution by HNO$_3$ + HClO$_4$ %											
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO$_2$	NiO	Cr$_2$O$_3$	CoO	P$_2$O$_5$			
A	21.9	13.1	8.4	0.39	0.23	0.08	0.05	0.01	0.01			
AC	24.8	15.7	7.4	0.68	0.24	0.03	0.02	0.01	0.01			
C2	27.6	15.9	9.0	0.67	0.23	0.08	0.03	0.01	0.01			

Horizon	Solution by HNO$_4$ + HClO$_4$ me %											
	Ca	Mg	K	Na								
A	25	86	18	2.3								
AC	19	87	20	3.7								
C2	19	174	19	5.6								

HAPLIC KASTANOZEM Kh

Classification	Australia: Chernozems. Um 6.11
Reference	Stace *et al.*, 1968. Profile 13B, p. 133. Abermusden fine sandy loam.
Location	Upper Hunter valley, New South Wales; 32°16′S, 150°52′E
Altitude	170 m
Physiography	Flat smooth alluvial terrace with minor waterways
Drainage	Well drained
Parent material	River alluvium
Vegetation	Cleared, irrigated pasture
Climate	Semiarid peripampean; Sm; 600 mm rainfall

Profile description

Ah1	**0-10 cm**	Very dark greyish brown (10YR 3/2) fine sandy loam; crumb structure; friable; diffuse boundary.
Ah2	**10-36 cm**	Dark brown to brown (10YR 4/3 dry) fine sandy loam; granular structure; friable; diffuse boundary.
Bw	**36-61 cm**	Very dark brown (10YR 2/2, 4/2 dry) fine sandy loam; weakly developed blocky structure; friable; diffuse boundary.
BC	**61-76+**	Dark brown to brown (10YR 4/3 dry) fine sandy loam; irregular blocky structure; friable.

HAPLIC KASTANOZEM

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—10	7.7		29	30.1	100	21	7.9	0.8	0.4			0.04
Ah2	10—36	7.7											0.03
Bw	36—61	7.7		32	34.3	100	24	9.4	0.3	0.6			0.03
BC	61—76	8.0		31	33.8	100	23	9.8	0.4	0.6			0.02

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.03	0.01		0.17		3.0		2	55	22	21	fine sandy loam
Ah2	0.07	0.03		0.12		2.7		7	53	20	20	fine sandy loam
Bw	0.04	0.01		0.11		2.7		2	51	26	21	fine sandy loam
BC	0.03	0.01		0.09		2.6		2	51	24	23	fine sandy loam

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Avail. P mg %			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5							
Ah1	63.8	15.9	8.5	1.6	0.12	0.27	7	20	5	3.9			
Bw	62.1	16.6	8.4	1.5	0.14	0.28	6	20	5	2.7			
										4.1			

CHROMIC LUVISOL Lc

Classification	Papua New Guinea; Terra Rossa
Reference	Haantjens *et al.*, 1967, p. 50-51. Profile WCV-P19
Location	Papua, northeast of Baniara; 9°39'S, 149°57'E
Altitude	15 m
Physiography	Gently undulating coral limestone plain with scattered rock outcrops
Drainage	Well drained
Parent material	Limestone
Vegetation	Grassland with shrubs
Climate	Humid semihot equatorial; 1 500-2 500 mm rainfall

Profile description

A	**0-10 cm**	Dark brown (7.5YR 3/2 moderately dry) clay; moderately developed very fine granular and weakly developed medium subangular blocky structure; hard, friable; clear undulating boundary.
BA	**10-20 cm**	Dark reddish brown (5YR 3/3) clay; weakly developed fine granular structure; friable; clear boundary.
Bt1	**20-30 cm**	Dark reddish brown (2.5YR 3/4) clay; weakly developed very fine blocky structure; friable.
Bt2	**30-75 cm**	Dark red (2.5YR 3/6) clay; structureless; very friable; abrupt boundary.
C	75+	Limestone

CHROMIC LUVISOL

Papua New Guinea

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	5.8		22	19.0	86	13.0	5.6	0.6	0.4			
BA	10—20	5.5		14	9.8	69	6.2	3.0	0.3	0.3			
Bt1	20—30	5.4		11	7.2	65	5.0	1.8	0.2	0.2			
Bt2	30—75	5.6											

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			5.9	0.4	15			4	9	18	69	clay
BA			3.8	0.2	19			3	11	13	73	clay
Bt1								3	9	11	77	clay
Bt2								1	3	3	93	clay

FERRIC LUVISOL Lf

Classification	Australia: lateritic podzolic soils. Dy 3.61
Reference	Northcote and Tucker, 1948, p. 72, 81. Seddon gravelly sandy loam
Location	Kangaroo Island, 35°46'S, 137°21'E
Altitude	140 m
Physiography	Undulating top of eroded plateau remmant
Drainage	Strongly impeded by argillic horizon
Parent material	Residual on truncated laterite profile
Vegetation	Dry sclerophyllous forest to low sclerophyllous scrub
Climate	Marine mediterranean; W1; 560 mm rainfall

Profile description

Au1	**0-4 cm**	Brownish grey loamy sand; some organic matter; some ironstone gravel; scattered surface gravel in places.
Au2	**4-10 cm**	Dull light brown or yellowish brown loamy sand; some ironstone gravel.
As	**10-18 cm**	Dull yellowish brown or light brown loamy sand; moderate to large amounts of ironstone gravel.
ABs	**18-27 cm**	Light yellowish brown sandy clay loam; ironstone gravel.
Bt1	**27-76 cm**	Light yellowish brown clay, mottled brown and yellowish grey; some ironstone gravel.
Bt2	**76-112 cm**	Light yellowish brown to yellowish brown clay, mottled red and grey; some ironstone gravel.
C	**112+**	Variously mottled clay with red and light grey prominent; ferruginous rock fragments in places.

FERRIC LUVISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	6.3		10.4	4.0	38	2.5	1.0	0.4	0.1			
ABs	10—36	5.8		7.1	2.3	32	0.7	1.0	0.4	0.2			
Bs	36—46	6.4		6.3	3.0	49	0.9	1.5	0.4	0.2			
Bt1	46—56	5.8		19.5	10.1	52	2.4	6.1	0.7	0.9			
Bt2	84—145	5.1		22.6	9.7	43	0.8	7.4	0.5	1.1			
C	145—183	4.8		23.9	9.8	41	0.8	6.3	0.2	2.6			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total		% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.02		1.4	0.06	25		19	12	73	6	9	sandy loam
ABs	0.05		0.7	0.03	25		61	12	71	5	12	sandy loam
Bs	0.03		0.3	0.02			72	19	60	6	15	sandy loam
Bt1	0.18		0.3	0.03			18	3	23	5	69	clay
Bt2	0.15		0.1	0.01			21	9	14	4	73	clay
C	0.49		0.2	0.02			35	5	12	3	80	clay

GLEYIC LUVISOL Lg

Classification	New Zealand: weakly leached gleyed yellow-grey earth
Reference	New Zealand Soil Bureau, 1968, p. 34-35. Marton silt loam
Location	Marton Experimental Farm; 40°04'S, 175°23'E
Altitude	150 m
Physiography	Flat site on undulating wide coastal plain
Drainage	Poorly drained
Parent material	Loess and volcanic ash
Vegetation	Dicotylous-podocarp forest
Climate	Warm marine; 1 000 mm rainfall

Profile description

Ah	**0-23 cm**	Very dark greyish brown (10YR 3/2) silt loam; moderately developed fine granular structure grading into subangular blocky below 8 cm; friable; abundant roots; fine bluish black concretions at 20 cm; distinct irregular boundary.
ABg	**23-33 cm**	Pale brown (10YR 6/3) clay loam; many distinct fine strong brown mottles and greyish brown casts; weakly developed fine subangular blocky structure; friable; many roots; indistinct boundary.
Btg	**33-46 cm**	Mottled pale brown and strong brown clay loam; weakly developed fine to medium blocky structure; firm; few roots; distinct boundary.
2Cg	**46-51 cm**	White sandy loam, prominent yellowish red mottles; structureless.
3Cg	**51-76 cm**	Pale grey (10YR 7/1) clay loam; many medium distinct strong brown mottles forming a reticulate pattern; weakly developed medium blocky structure; very firm; diffuse boundary.
3C	76+	Yellowish brown to brownish yellow (10YR 5/8-6/8) clay loam; many pale grey veins; massive; firm.

GLEYIC LUVISOL

New Zealand

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—8	5.9	4.3	17.5	9.7	55	5.9	2.4	0.3	0.5			
Ah2	8—23	5.8	4.2	13.1	5.3	40	4.0	1.3	0.1	0.1			
ABg	23—33	5.8	4.1	11.5	6.5	56	3.7	2.4	0.1	0.2			
Btg	33—46	5.9	4.2	14.5	11.3	78	5.2	5.5	0.1	0.7			
3Cg	51—76	5.2	4.0	13.2	8.6	65	2.6	5.4	0.1	0.5			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			4.5	0.38	12			41		31	27	silt loam
Ah2			2.8	0.23	12			44		29	24	silt loam
ABg			0.9	0.10	9			38		32	30	clay loam
Btg			0.7	0.09	8			31		32	37	clay loam
3Cg			0.3	0.04	8			35		34	31	clay loam

Horizon	Phosphorus mg %						Tamm's oxalate %			Bulk density	Field capacity	Wilting point	
	Total	Org.	Truog	$N H_2SO_4$	Pretention		Al	Fe					
Ahl	70	43	1.0	10	31		0.28	0.88		0.96	44	20	
Ah2	53	32	0.7	8	32		0.28	0.84		1.13	31	15	
AB g	27	11	0.5	2	32		0.28	0.67		1.32	29	20	
Btg	21	8	1.0	2	41		0.40	0.70		1.13	39	28	
3Cg	16	3	0.5	1	28		0.19	0.69		1.47	33	21	

CALCIC LUVISOL Lk

Classification	Australia: red-brown earths. Dr 2.23
Reference	Litchfield, 1951, p. 23, 32. Urrbrae fine sandy loam
Location	Waite Agricultural Research Institute, Glen Osmond, South Australia; 34°59′S, 138°37′E
Altitude	90 m
Physiography	Gentle alluvial-colluvial slope
Drainage	Well drained
Parent material	Colluvium and alluvium from slates and phyllites
Vegetation	*Eucalyptus odorata* savanna woodland
Climate	Cool subtropical mediterranean; Wl; 570 mm rainfall

Profile description

Ah1	**0-18 cm**	Brown to light reddish brown fine sandy loam to loam; firm, but crumbly, dry and mellow, moist; diffuse boundary.
Ah2	**18-33 cm**	Light reddish brown silt loam to fine sandy loam; firm, compact; diffuse boundary.
AB	**33-38 cm**	Light reddish brown clay loam; subangular blocky structure developing at bottom of horizon; firm, compact.
Bt	**38-89 cm**	Reddish brown to dark reddish brown clay; subangular blocky to granular structure at top of horizon tending to prismatic with depth; friable to firm; sheen on ped faces; some small black concretions.
Bck	**89-175 cm**	Reddish brown clay; granular structure; friable; hard nodular or soft amorphous carbonate concretions.

CALCIC LUVISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %								$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na		
Ah1	0—18	5.7										
Ah2	18—33	5.9		13.5	7.2	53	4.6	1.6	0.8	0.2		
Bt1	33—76	6.6		11.7	7.5	64	4.2	2.0	0.9	0.4		
Bt2	76—89	7.2		32.3	24.9	77	15.2	6.9	1.8	1.0		
Bck	89—114	8.6		29.6	25.7	87	17.0	6.8	1.2	0.7		9.8
BC	114—175	8.5										2.4

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.06	0.02	1.4	0.11	13			3	43	34	20	fine sandy loam
Ah2	0.08	0.04	0.6	0.07	9			2	41	32	25	silt loam
Bt1	0.07	0.03	0.7	0.09	8			1	17	15	67	clay
Bt2	0.08	0.04	0.5	0.06	9			1	25	26	48	clay
Bck	0.09	0.04	0.4	0.04	9			1	22	32	35	clay
BC	0.13	0.06	0.2	0.03	7			1	24	36	36	clay

ORTHIC LUVISOL Lo

Classification	Australia: grey-brown podzolic soils. Dy 3.22
Reference	Stace *et al.*, 1968. Profile 31C, p. 316. Springton light sandy loam
Location	Barossa district, South Australia; 34°42′S, 139°04′E
Altitude	400 m
Physiography	Moderate slightly concave slope in undulating landscape
Drainage	Slightly impeded by B horizon
Parent material	Paleozoic micaschist
Vegetation	Savanna woodland
Climate	Cool subtropical mediterranean; Wm; 535 mm rainfall

Profile description

Ah1	**0-5 cm**	Very dark greyish brown (10YR 3/2, 4/2 dry), with lighter patches, light sandy loam; crumb structure; mellow; top of main root zone; distinct boundary.
Ah2	**5-30 cm**	Very dark greyish brown (10YR 3/2) light sandy loam, slightly micaceous; weakly developed platy structure; main root zone; diffuse boundary.
Ah3	**30-43 cm**	Dark greyish brown to greyish brown (10YR 4/2-5/2 dry) sand, slightly micaceous; platy; cemented (dry); rock fragments up to 8 cm; clear wavy boundary.
Bt1	**43-48 cm**	Yellowish brown (10YR 5/4), with greyish brown veins and rusty brown inclusions, sandy clay, micaceous; massive; hard; fragments of weathered rock; diffuse boundary.
Bt2	**48-61 cm**	Weak red to dusky red (2.5YR 4/2-3/2) micaceous clay with red and yellowish brown mottles and greyish brown coatings on ped faces; very coarse breaking to fine angular blocky structure; subplastic; fragments of weathered rock; horizon fingers into horizon below; diffuse boundary.
BC	**61-74 cm**	Red and yellowish brown weathered rock with brownish grey clayskins on the rock fragments.
C	**99-104 cm**	Light grey weathered micaschist.

ORTHIC LUVISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—5	6.0			6.3		3.8	1.6	0.5	0.4			
Ah2	5—28	5.4			3.4		1.9	0.9	0.3	0.3			
Ah3	30—41	5.9											
Bt1	43—48	6.2			9.8		4.1	4.9	0.2	0.6			
Bt2	48—61	6.3			16.9		6.5	9.1	0.3	1.0			
C	74—104	7.0											

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.03	0.01		0.26		4.9		25	59	10	6	sandy loam
Ah2	0.02	0.01					2	25	59	7	9	sandy loam
Ah3	0.01	0.01					24	24	60	7	9	sand
Bt1	0.02	0.01		0.05		0.8	1	26	44	10	20	sandy clay
Bt2	0.02	0.01		0.06		0.9		18	32	7	43	clay
C	0.04	0.02					47	28	58	7	7	weathered rock

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5						
Ah1-2	78.6	10.3	2.6	0.8	0.02	0.10	13	81	11			
Bt2	63.6	18.8	8.8	0.9	0.02	0.14	6	19	4			

DYSTRIC NITOSOL Nd

Classification	Australia: red podzolic soils. Gn 3.14
Reference	McArthur, 1964. Profile 433, p. 50. Moonpar association
Location	Dorrigo-Ebor-Tyringham area, New South Wales; 30°14'S, 152°37'E
Altitude	730 m
Physiography	Smooth rounded hills
Drainage	Well drained
Parent material	Granite
Vegetation	Forest
Climate	Temperate pampean; Sm; 280 mm rainfall

Profile description

A	**0-15 cm**	Dark reddish brown (5YR 2/2) gritty loam; weakly developed crumb structure; porous.
AB	**15-25 cm**	Dark brown and dark red mottled gritty light clay; crumbly; porous
Bt1	**25-61 cm**	Dark red (10R 3/6) gritty clay; crumb structure; firm; porous.
Bt2	**61-91 cm**	Dark red (10R 3/6) gritty clay; strongly developed fine angular blocky structure; compact.
Bt3	**91-183 cm**	Dark red (10R 3/6) gritty clay; strongly developed fine angular blocky structure; plastic.

DYSTRIC NITOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—15	5.9		30.0	5.0	17	3.3	1.4	0.3	0			
AB	15—25	5.8											
Bt1	25—61	5.7		8.0	0.8	10	0.2	0.5	0.1	0			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			3.7	0.18	20						27	
Bt1											44	

Horizon	Phosphorus mg %												
	Total	Soluble											
A	24	0.4											
Bt1	14												

DYSTRIC HISTOSOL Od

Classification	New Zealand: organic soil of lowland bog
Reference	New Zealand Soil Bureau, 1968, p. 108-109. Otanomomo peat
Location	Invercargill, Southland; 46°24′S, 168°21′E
Altitude	35 m
Physiography	Almost flat peat bog
Drainage	Very poorly drained
Parent material	Sphagnum peat
Vegetation	Sphagnum moss, rushes
Climate	Humid mild patagonian marine; 1 000 mm rainfall

Profile description

H1	**0-20 cm**	Dark reddish brown (5YR 3/3) wet fibrous peat; mainly sphagnum with many roots of wire rush; clear boundary.
H2	**20-46 cm**	Strong brown to dark reddish brown (7.5YR 5/6 to 5YR 3/4) semifibrous peat; no roots; clear boundary.
H3	**46-89 cm**	Dark brown (7.5YR 3/2) peat, with some discontinuous paler layers; dominantly sphaghum, some wire rush.
H4	**89-110 cm**	Dark reddish brown (5YR 3/3) peat; many small sticks and few larger roots and stems; much wire rush and sedge.
H5	**110+**	Dark reddish brown (2.5YR 3/4) peat, well developed with few fibres of old roots in places; small logs and stumps.

DYSTRIC HISTOSOL

New Zealand

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
H1	0—20	4.4	3.4	92	28	30	9.2	14.8	1.1	2.5			
H2	20—46	4.5	3.1	112	35	29	10.2	25.7	0.5	2.7			
H3	46—89	4.6	3.1	109	23	21	5.9	15.3	0.5	2.3			
H4	89—110	4.5	2.9	146	31	21	7.6	20.0	0.2	2.3			
H5	110—135	4.5	2.8	155	29	19	6.6	20.2	0.2	2.2			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
H1			48.4	1.43	34							
H2			50.0	0.80	62							
H3			52.2	0.94	55							
H4			55.1	1.36	40							
H5			60.5	1.08	56							

Horizon	Phosphorus mg %						Tamm's oxalate %			Bulk density		
	Total	Org.	Truog	NH_4SO_4	P retention		Al	Fe				
H1	56	43	4.0	9	0		0.09	0.18		0.04		
H2	22	19	1.0	3	0		0.05	0.06		0.03		
H3	18	16	0.5	2	0		0.03	0.02				
H4	14	12	0.5	2	0		0.05	0.06				
H5	15	13	0.2	1	0		0.06	0.06		0.13		

PLACIC PODZOL Pp

Classification	New Zealand: podzolized yellow-brown earth
Reference	New Zealand Soil Bureau, 1968, p. 62-63. Tautuku silt loam
Location	Chaslands, southern South Island; 46°34′S, 169°10′E
Altitude	75 m
Physiography	Short easy rolling (7°) spur facing south
Drainage	Moderately well drained
Parent material	Loess from tuffaceous greywacke
Vegetation	Forest
Climate	Cool marine; 1 400 mm rainfall

Profile description

O	**50-0 cm**	Thin dry litter of leaves and twigs on dark reddish brown (5YR 2/2) to very dusky red (2.5YR 2/2) decomposed organic matter; many roots in top 13 cm, decreasing to very few in lowest 5 cm; clear boundary.
E	**0-5 cm**	Yellowish brown (10YR 5/4), pale yellow dry, silt loam; few dark grey humus stains; weakly developed fine to medium blocky structure; friable to very friable; slightly vesicular; clear boundary.
EB	**5-18 cm**	Dark brown (10YR 3/3) silt loam, aggregate faces very dark brown (10YR 2/2); moderately developed medium to coarse blocky structure tending to medium platy at top of horizon; firm; diffuse boundary.
Bhs	**18-28 cm**	Dark brown (10YR 3/3) heavy silt loam, ped faces black (10YR 2/1), interiors pale yellowish brown (10YR 6/4); weakly developed medium blocky structure; firm, moderately sticky, plastic; clear boundary.
Bms	**28-30 cm**	Ironpan; top 6 mm dark reddish brown (5YR 2/2); hard; lower 6 mm yellowish red (5YR 5/8); softer; clear wavy boundary.
BC	**30-41 cm**	Reddish yellow (7.5YR 6/8) and brownish yellow (10YR 6/6) silt loam, some black (5YR 2/1) stains in thin streaks on cracks; massive to weakly developed fine blocky and coarse platy structure.
C	**41+**	Pale yellowish brown (2.5Y 6/4) silt loam with some weathering fragments of rocks, some dark brown (7.5YR 4/4) stains in cracks; massive to very weakly developed very coarse blocky structure; firm.

PLACIC PODZOL

New Zealand

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
O	50—0	4.1	2.7										
E	0—5	4.1	2.8	41.9	4.4	11	0.5	3.5	0.2	0.7			
EB	8—28	4.7	3.4	43.1	2.7	6	0.1	1.9	0.1	0.3			
Bms	28—30	5.0	3.6	25.8	1.3	5	0	0.5	0.1	0.2			
BC	30—41												

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
O			31.3	0.35	86			3		64	33	silt loam
E			5.3	0.15	30			22		38	40	silty clay loam
EB			1.2	0.07	17							
Bms												
BC								30		41	29	silt loam

Horizon	Phosphorus mg %						Tamm's oxalate %			Bulk density	Field capacity	Wilting point	
	Total	Org.	Truog	NH_4SO_4	P retention		Al	Fe					
O	42									0.20			
E	27	12	2.0	12	15		0.14	0.12			130	32	
EB	31	15	0.2	6	76		0.58	0.57		0.71	71	39	
Bms													
BC	28	9	0.2	9	79		0.65	1.51		1.25	45	30	

ALBIC ARENOSOL Qa

Classification	Australia: lateritic podzolic soils. Uc 2.12
Reference	Stace *et al.*, 1968. Profile 35E, p. 357. Kauring sand
Location	Eastern Darking range, Western Australia; 31°46′S, 116°28′E
Altitude	340 m
Physiography	Gentle lower slope (1.5°) of a generally concave slope falling from a laterite breakaway
Drainage	Strongly impeded by massive laterite horizon at 90 cm
Parent material	Sand over laterite developed from Precambrian granite
Vegetation	Cleared from sclerophyll forest
Climate	Subtropical mediterranean; WW1; 460 mm rainfall

Profile description

A	**0-10 cm**	Very dark grey (10YR 3/1, 5/1 dry) sand; structureless; loose; nonwetting.
AE	**10-15 cm**	Very dark grey passing to grey sand; structureless; loose; a little pisolitic ferruginous gravel up to 1 cm; gradual boundary.
Es1	**15-30 cm**	Grey (10YR 4.5-5.5/1, 6/1 dry) sand; structureless; loose; ferruginous gravel, mainly up to 5 cm, increasing with depth; diffuse boundary.
Es2	**30-90 cm**	Light brownish grey (10YR 6/2 moist) sand; structureless; loose; much ferruginous gravel and stone, up to 15 cm; clear irregular boundary.
Bms	**90-115 cm**	Yellowish brown hard laterite overlying yellowish brown compact clayey sand.
	200 cm	Pink clay at top of pallid zone.
	400 cm	Mottled reddish brown and white gritty clay with a few pieces of pale hard weathered granite (1 cm).
	600 cm	Pink clay loam, gritty with angular primary quartz grains.
	1 100 cm	Weak red gritty clay loam.
	1 560 cm	Unweathered hard granite.

ALBIC ARENOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me.%									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	6.5		8	5.6	70	4.0	1.3	0.1	0.2			
Es1	15—20	6.2		3	1.8	60	1.0	0.7		0.1			
Es2	30—60	6.4		2	1.1	55	0.4	0.6		0.1			
Bms	100—115	6.6		2	1.4	70	0.4	0.8		0.2			
	at 400	5.5		6	3.6	60	0.1	1.8		1.7			
	at 700	5.1		8	5.3	66	0.1	1.3	0.1	3.8			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.01	0					6	75	22	2	1	sand
Es1	0.01	0					31	70	27	2	1	sand
Es2	0.01	0					69	67	29	3	1	sand
Bms	0.01	0					60					
—	0.13	0.13					14	41	11	15	33	clay
—	0.30	0.30					10	29	11	30	30	gritty clay

Horizon	Silicate analysis %									Avail. P mg %	Free Fe_2O_3 %		
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5							
A	97.8	0.9	0.3	0.20	0	0.03				2.2	0.20		
Es1	98.5	0.8	0.1	0.24	0.01	0				0.4	0.20		

FERRALIC ARENOSOL Qf

Classification	Australia: earthy sands. Uc 5.22
Reference	Stace *et al.*, 1968. Profile 6A, p. 48. Norpa series
Location	Merredin district, Western Australia; 31°28′S, 118°13′E
Altitude	300 m
Physiography	Midslope on sandsheet moderately sloping from divide crest to valley floor; the Ulva surface
Drainage	Very well drained
Parent material	Colluvial sandsheet
Vegetation	Sandplain scrub
Climate	Subtropical mediterranean; Wl; 300 mm rainfall

Profile description

A	**0-10 cm**	Light yellowish brown (10YR 6/4) for surface 3 cm then yellow (10YR 7/6) loamy coarse sand; weakly coherent; earthy; a little grit and organic matter; diffuse boundary.
Bu1	**10-30 cm**	Yellow (10YR 7/8) clayey sand; weakly coherent; earthy; a little grit in top 10 cm; diffuse boundary.
Bu2	**30-90 cm**	Yellow (10YR 7/8) coarse sandy loam; weakly coherent; earthy; a little soft sesquioxidic gravel from 60-90 cm; diffuse boundary.
Bs	**90-110 cm**	As above but with much sesquioxidic gravel; clear boundary.
C	**110+**	Indurated mottled zone.

FERRALIC ARENOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	5.5		4	1.5	38	0.5	0.8	0.1	0.1			
Bu1	10—20	4.7											
Bu1	20—30	4.6		3	0.9	30	0.3	0.4	0.1	0.1			
Bu2	30—60	5.0											
Bu2	60—90	4.8		3	3.1	100	0.8	1.4	0.1	0.8			
Bs	90—110	5.8											

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.03	0		0.01			4	58	24	4	14	loamy coarse sand
Bu1	0.01	0					3	58	24	6	12	clayey sand
Bu1	0.01	0		0.01			4	52	27	7	14	clayey sand
Bu2	0.02	0					6	58	23	6	13	coarse sandy loam
Bu2	0.12	0.11		0.01			18	40	40	7	13	coarse sandy loam
Bs	0.17	0.17					66	39	39	9	13	coarse sandy loam

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Free Fe_2O_3 %			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5							
A	83.9	13.3	2.8	0.41	0	0.01	11	79	8	1.0			
Bu2*	79.5	15.3	3.2	0.53	0	0.01	9	66	8				

* 30-60 cm.

CALCARIC REGOSOL Rc

Classification	Cook Islands: tropical recent soil from coral sand
Reference	Bruce, 1972. Muri sand
Location	Palmerston Island, Cook Islands; 18°05′S, 163°11′W
Altitude	2 m
Physiography	Almost flat
Drainage	Very well drained
Parent material	Coral sand
Vegetation	Coconut palms
Climate	Humid equatorial; 2 068 mm rainfall

Profile description

A	**0-3 cm**	Dark reddish brown (5YR 3/2) loamy sand; very weakly developed subangular blocky structure; many roots; gradual boundary.
AC	**3-15 cm**	Dark grey (5YR 4/1) slightly loamy sand; very weakly developed subangular blocky structure breaking readily to single grains; friable; many roots; clear boundary.
C	15+	Pinkish grey (7.5YR 7/2) medium sand; structureless; loose.

CALCARIC REGOSOL
Cook Islands

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	CaCl$_2$	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—3	7.7	7.4	16.2	free lime			2.9	0.1	0.2			78
AC	3—15	7.8	7.4	10.2	free lime			2.9	0.1	0.2			82

Horizon	Sol. salts %		Organic matter									
	Total		% C	% N	C/N							
A	0.03		4.3	0.38	11							
AC	0.02		2.7	0.25	11							

Horizon	Phosphorus mg %						Tamm's oxalate %						
	Total	Truog	$N H_2SO_4$	% P retention			Al	Fe					
A	818	30	803	73			0.02	0.02					
AC	960		730	78			0.02	0.02					

EUTRIC REGOSOL Re

Classification	Australia: Terra Rossa soils. Uc 6.13
Reference	Stace *et al.*, 1968. Profile 27A, p. 284
Location	Southeast district, South Australia; 36°52'S, 140°32'E
Altitude	40 m
Physiography	Gentle west-facing slope of a stranded beach ridge, occasional limestone outcrops
Drainage	Very well drained
Parent material	Pleistocene dune limestone (calcarenite)
Vegetation	Cleared from savanna
Climate	Marine mediterranean; Wm; 500 mm rainfall

Profile description

A	0-10 cm	Reddish brown (5YR 4/6 dry) sandy loam; massive breaking into irregular angular clods (up to 4 cm); hard, compact; porous; a little hard carbonate; common grass roots; arbitrary boundary.
AC	10-20 cm	Dark red (2.5YR 3/6 dry) sandy loam; massive breaking to irregular angular clods; hard, compact; porous; fewer roots; animal holes; arbitrary boundary.
C	20-60 cm	Dark red (2.5YR 3/6 dry) loamy sand, sandy loam deeper; massive breaking to irregular angular clods; firm, compact to moderately compact; porous; few roots; clear irregular boundary.
R	60+	Massive limestone with a few mm of softer material, up to 10 mm of dense hard laminated material, then porous rock containing quartz grains with cross-bedded porous calcarenite containing quartz grains below 200 cm.

EUTRIC REGOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—10	7.1		7	11.2	100	9.6	0.9	0.5	0.2			0.39
AC	10—20	6.9											
C1	30—50	7.0		6	5.4	90	4.1	0.9	0.3	0.1			
C2	50—60	7.1		7	5.8	83	4.4	1.1	0.2	0.1			
R	70—150												83

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.05	0.01		0 12		2.0		18	60	7	15	sandy loam
AC	0.02	0		0.06				17	62	8	13	sandy loam
C1	0.01	0		0.04		0.6		18	60	7	15	sandy loam
C2	0.10	0		0.04		0.7		18	59	6	17	sandy loam
R	0.07	0.02		0		0.1						

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$	Avail. P mg %			
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO	P$_2$O$_5$							
A	87.6	5.6	2.7	0.41	0.05	0.08	27	85	20	0.9			
AC	88.3	5.9	2.8	0.42	0.03	0.07	25	84	19				
C1										0.4			
C2										0.5			
R										0.7			

ORTHIC SOLONETZ So

Classification	Australia: Solonetz. Dy 3.43
Reference	Stace *et al.*, 1968. Profile 16B, p. 158
Location	Upper southeast, South Australia; 36°17′2, 140°50′E
Altitude	110 m
Physiography	Level plain with fall of 9 m/km to the south
Drainage	Impeded by clay horizon
Parent material	Cainozoic sediments
Vegetation	Savanna woodland
Climate	Marine mediterranean; Wm; 500 mm rainfall

Profile description

Ah1	**0-4 cm**	Dark brown to brown (7.5YR 4/2) sandy loam; weakly developed crumb structure; *mellow; some grass roots and earthworms;* diffuse boundary.
Ah2	**4-10 cm**	Brown (7.5YR 5/4) sand; pseudocrumb structure; mellow; a few roots and worm channels; diffuse boundary.
A/B	**10-15 cm**	Light brownish grey to pale brown (10YR 6/2-6/3) sand between domed columns; clear boundary.
Btn1	**15-17 cm**	Upper part of domed colums (10-17 cm); mottled reddish yellow (5YR 6/6), light red (2.5YR 6/8) with organic stained brown to dark brown (7.5YR 4/2) cracks, clay; plastic; many fine roots.
Btn2	**17-23 cm**	Median part of large columns; reddish yellow (7.5YR 6/6) with dark grey stainings, clay with sand; breaking to coarse blocks; firm; a few fine roots.
Btn3	**33-47 cm**	Basal part of large columns; finely mottled reddish yellow (7.5YR 6/6), very *pale brown (10YR 7/4) and greyish brown, sandy clay; breaking to coarse blocks;* firm; diffuse boundary.
Btn4	**47-57 cm**	Light brown and yellowish brown sandy clay to sandy clay loam; weak structure; friable; clear boundary.
Bk	**57-107 cm**	Light brown to yellow (10YR 5-6/4-6) fine sandy clay loam; weak structure; friable; finely dispersed carbonate decreasing at depth.
BC	**107-135 cm**	Motthed light brown to light yellow clay; weak structure; firm; pockets of carbonate concretions and some finely dispersed carbonate; a few ferruginous concretions and black inclusions; clear boundary.
C1	**135-140 cm**	Light brownish yellow fine sandy clay loam; weak structure; very friable; a little carbonate; clear boundary.
C2	**140-155 cm**	*Light yellow, reddish brown and light yellowish brown clay; weak structure.*

ORTHIC SOLONETZ

Australia

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—4	7.8											0.12
Ah2	4—10	6.8		7	5.7	81	3.8	1.3	0.4	0.2			
Btn1	15—17	6.8		20	17.4	87	4.6	8.7	0.8	3.3			
Btn4	47—57	8.9		21	20.7	99	3.1	10.0	1.1	6.5			0.03
Bk	84—107	9.4											18.0
BC	127—135	8.9		26	27.8	100	4.9	12.0	1.5	9.4			0.01

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1	0.05	0.01		0.14		3.3		9	80	4	7	sandy loam
Ah2	0.02	0.01		0.08		2.1		10	78	5	7	sand
Btn1	0.05	0.01		0.07		1.6		9	58	1	32	clay
Btn2	0.22	0.11						9	60	1	30	sandy clay
Bk	0.41	0.19						8	45	1	28	sandy clay
BC	0.39	0.19						8	49	0	43	clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$			
	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	TiO$_2$	MnO	P$_2$O$_5$						
Ah1	94.4	2.7	1.0	0.3	0.02	0.03	60	256	48			
Btn2	83.0	9.3	3.7	0.5	0.01	0.03	15	59	12			

HUMIC ANDOSOL Th

Classification	New Zealand: moderately leached yellow-brown loam
Reference	New Zealand Soil Bureau, 1968, p. 80-81. Tirau silt loam
Location	Tirau; 38°00'S, 175°47'E
Altitude	120 m
Physiography	Near crest of easy rolling ridge; slope 2 degrees; aspect easterly
Drainage	Well drained
Parent material	Volcanic ash, mainly andesitic
Vegetation	Dicotylous-podocarp forest, now grasses and fern
Climate	Warm, temperate; 1 400 mm rainfall

Profile description

Ah	**0-18 cm**	Dark reddish brown (5YR 3/2) silt loam; moderately developed very fine crumb to granular structure; friable; abundant roots; distinct irregular boundary.
AB	**18-30 cm**	Dark brown (10YR 3/3) sandy loam; moderately developed fine granular structure; very friable; many roots; indistinct irregular boundary.
2B	**30-50 cm**	Yellowish brown (10YR 5/6) sandy loam; moderately developed medium subangular blocky structure; firm to friable; dark yellowish brown very thin coatings on peds; few roots.
2C	**50+**	Yellowish brown sandy loam to loamy sand; massive; firm; few small irregular pores with dark yellowish brown linings.

HUMIC ANDOSOL

New Zealand

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ah1	0—8	5.6	4.9	36.8	17.8	48	11.8	4.6	1.4	0.2			
Ah2	8—18	5.4	4.9	28.1	7.7	27	5.2	1.5	0.9	0.1			
AB	20—30	5.9	5.1	15.6	1.5	10	1.2	0.4	0.5	0			
2B	33—51	6.3	5.3	15.1	3.6	24	2.5	0.5	0.7	0.1			
2C	61—76	6.8	5.4	14.1	5.6	40	2.4	2.1	0.9	0.3			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			10.6	0.87	12			54		29	17	silt loam
Ah2			7.2	0.60	12							
AB			2.3	0.24	10			75		20	5	loamy sand
2B			1.1	0.12	9			78		15	7	loamy sand
2C			0.5	0.06	9							

Horizon	Phosphorus mg %						Tamm's oxalate %			Bulk density		
	Total	Org.	Truog	$N H_2SO_4$	P retention		Al	Fe				
Ah1	143	101	0.5	33	95		3.2	0.6		0.52		
Ah2												
AB	98	45	0.2	38	98		4.3	0.9		0.62		
2B	60	17	0.2	26	95		4.2	1.1		0.64		
2C	34	7	0.2	6	92		2.8	1.1		0.76		

MOLLIC ANDOSOL Tm

Classification	Hawaii: Typic Eutrandept
Reference	Foote *et al.*, 1972, p. 47, 220-221. Io silt loam
Location	Maui Island; 29°39'20''N, 156°24'40''W
Altitude	300-750 m
Physiography	Smooth low mountain slopes, 4- to 14-degree slopes
Drainage	Well drained
Parent material	Volcanic ash and material weathered from cinders
Vegetation	Grasses, shrubs, trees
Climate	Semihot tropical; 650-900 mm rainfall

Profile description

Ap	**0-25 cm**	Very dark brown (10YR 2/2, 4/2 dry) silt loam; weakly and moderately developed fine and very fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many fine and very fine pores; abundant fine roots; clear, wavy boundary.
AB	**25-43 cm**	Dark brown (7.5YR 3/2, 4/2 dry) silty clay loam; weak and moderately developed fine subangular blocky structure; hard, friable, sticky, plastic; many fine and very fine pores; abundant fine roots; gradual wavy boundary.
Bw1	**43-64 cm**	Dark brown (10YR 3/3, 4/3 dry) clay loam; weakly developed fine and medium subangular blocky structure; hard, friable, sticky, plastic; many fine pores; abundant fine roots; thin dark coatings like organic stains on peds; compact in place; clear smooth boundary.
Bw2	**64-77 cm**	Dark reddish brown (5YR 3/3, 4/4 dry) and yellowish red (5YR 4/6, 5/6 dry) clay loam; weakly and moderately developed fine subangular blocky structure; hard, friable, sticky, plastic; many medium and fine pores; abundant fine roots; 20 percent fine cinders; abrupt smooth boundary.
C	**77-100 cm**	Black cinders (1-10 cm) single grain; extremely hard, loose; few fine roots.

MOLLIC ANDOSOL

Hawaii

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
Ap	0—23	6.7	5.8	61.1	54.0	88	35.8	11.7	6.1	0.4			
AB	23—41	7.4	6.5	65.5	84.7	100	55.5	22.3	4.2	1.7			
Bw1	41—64	7.4	6.4	63.1	61.3	97	42.7	12.3	0.3	6.0			
Bw2	64—76	7.8	6.4	54.3	49.7	92	34.9	11.7	0.9	2.2			
C	76—100	7.5	6.5	56.7	59.8	100	39.9	13.7	0.2	6.0			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ap			5.8	0.46	13							
AB			2.6	0.21	12							
Bw1			2.6	0.20	13							
Bw2			2.9									
C			0.8									

Horizon	Total analysis %									Bulk density	Moisture retention		
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5	Loss on ign.				1/3 atm	15 atm	
Ap	25.5	18.2	15.6	3.6	0.28	0.65	16.6			0.87	50	35	
AB	25.4	18.4	16.4	3.7	0.28	0.60	14.4			0.88	50	38	
Bwl	24.2	18.4	16.3	3.8	0.23	0.50	13.0			0.75	56	43	
Bw2	38.2	14.8	14.3	3.8	0.21	0.47	4.8			0.77	18	14	
C	27.3	19.6	17.9	4.1	0.20	0.23	10.7			0.76	58	51	

Horizon	Total analysis %									Free Fe_2O_3 %			
	CaO	MgO	K_2O	Na_2O									
Ap	2.20	4.08	0.50	0.41						12.4			
AB	2.11	4.06	0.34	0.39						15.2			
BW1	1.66	3.51	0.19	0.38						13.7			
Bw2	7.20	7.32	0.59	1.71						3.1			
C	1.25	4.21	0.11	0.28						15.2			

OCHRIC ANDOSOL To

Classification	New Zealand: moderately leached yellow-brown loam
Reference	New Zealand Soil Bureau, 1968, p. 82-83. Egmont black loam
Location	South Taranaki; 39°37′S, 174°16′E
Altitude	90 m
Physiography	Flattish part of easy rolling landscape
Drainage	Well drained
Parent material	Andesitic volcanic ash
Vegetation	Fern and scrub, now pasture
Climate	Warm marine; 1 000 mm rainfall

Profile description

Ah	**0-20 cm**	Black (10YR 2/1) loam; moderately developed fine subangular blocky structure; friable; abundant roots; irregular distinct boundary.
B	**20-46 cm**	Brown to dark greyish brown (10YR 5/3-4/3) loam (gritty); very weakly developed medium subangular blocky structure breaking to crumbs; very friable; some roots; some small creamy pieces of weathered pumice; distinct wavy boundary.
BC	**46-66 cm**	Yellowish brown (10YR 5/4) silt loam (gritty); massive to weakly developed fine blocky and some crumb structures; firm; some small pieces of creamy weathered pumice; some roots; indistinct boundary.
C	**66+**	Dark yellowish brown (10YR 4/4) heavy silt loam (gritty); greasy; massive; very firm; some small pieces of creamy weathered pumice; few roots down to 75 cm.

OCHRIC ANDOSOL

New Zealand

Horizon	Depth cm	pH H$_2$O	pH KCl	Cation exchange me % CEC	TEB	% BS	Ca	Mg	K	Na			CaCO$_3$ %
Ah1	0—8	6.0	4.9	36.9	18.8	51	12.6	5.4	0.6	0.7			
Ah2	8—15	6.0	5.0	31.2	14.5	46	10.5	3.9	0.3	0.4			
B	20—35	6.4	5.3	19.1	5.6	29	4.3	1.6	0.2	0.2			
BC	45—55	6.4	5.7	13.2	2.4	18	2.2	1.1	0.1	0.2			
C	75—90	6.4	5.7	14.2	3.2	23	2.3	1.9	0.1	0.1			

Horizon	Sol. salts		Organic matter % C	% N	C/N	% OM	Particle size analysis % Stones	Coarse sand	Fine sand	Silt	Clay	Texture
Ah1			12.3	0.93	13			55		23	22	loam
Ah2			8.7	0.71	12			56		26	18	silt loam
B			3.6	0.40	9			65		26	9	loamy sand
BC			1.7	0.20	9			67		21	12	sandy loam
C			1.1	0.15	7							

Horizon	Phosphorus mg % Total	Org.	Truog	NH$_4$SO$_4$	P retention		Tamm's oxalate % Al	Fe		Bulk density	Field capacity	Wilting point	
Ah1	256	136	0.5	98	99		3.7	1.4		0.86	67	40	
Ah2	238	125	0.5	100	92		3.3	1.9		0.82	58	34	
B	248	107	0.2	122	96		4.1	3.1		0.74	48	36	
BC	167	57	0.2	95	98		4.5	3.7		0.83	50	38	
C	127	50	0.2	63	97		4.7	2.9		0.85	56	42	

VITRIC ANDOSOL Tv

Classification	Solomon Islands: Livusaghata Land System, Vitrandepts
Reference	Land Resources Division, ODA. Profile Guadalcanal 148
Location	Savo Island, 2 km southeast of Kuikuila; 9°07′S, 159°49′E
Altitude	250 m
Physiography	Nearly level top of ridge crest, irregular microrelief
Drainage	Very well drained
Parent material	Probably andesitic agglomerate
Vegetation	Primary forest, canopy at 15 m, 50% closed
Climate	Semihot equatorial; 3 000-4 000 mm rainfall

Profile description

A	**0-13 cm**	Dark brown (10YR 3/3) loamy sand; very friable.
Bu1	**13-41 cm**	Olive grey (5Y 5/2) sand; loose.
Bu2	**41-74 cm**	Olive (5Y 5/3) stony sand; loose.
C1	**74-102 cm**	Light olive grey (5Y 6/2) sand; loose; patches of subangular black and white andesite.
C2	**102-122 cm**	As C1, split for sampling.

VITRIC ANDOSOL

Solomon Islands

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na	Al	H	
A	0—13	5.5		11.2	10.2	91	7.6	2.0	0.1	0.5			
Bu1	13—41	5.5		1.5	1.1	73	0.7	0.2	0.1	0.1			
Bu2	41—74	5.4		1.9	2.2	100	1.7	0.3	0.1	0.1			
C1	74—102	5.6		2.1	3.1	100	2.6	0.3	0.1	0.1			
C2	102—122	5.6		2.6	3.6	100	3.0	0.3	0.1	0.2			

Horizon	Sol. salts		Organic matter				Particle size analysis %					
			% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A			3.2	0.26	12			24	49	19	8	sandy loam
Bu1			0.3	0.02	14			15	60	19	6	sandy loam
Bu2			0.2	0.02	12			45	34	15	6	sandy loam
C1			0.2	0.02	9			48	34	13	5	sandy loam
C2			0.2	0.02	8			29	45	19	7	sandy loam

Horizon	Phosphorus mg %					Total %				Bulk density		
	Total	Olsen	NH_4F/HCL			K	Mg					
A	52	1.1	3.5			0.15	0.54			0.90		
Bu1	59	0.2	9.3			0.24	0.57			1.26		
Bu2	52	0.4	7.5			0.19	0.53			1.42		
C1	44	0.8	9.0			0.15	0.46			1.29		
C2	49	1.0	11.6			0.19	0.60			1.23		

CHROMIC VERTISOL Vc

Classification	Australia: grey, brown and red clays. Ug 5.24
Reference	Stace *et al.*, 1968. Profile 10c, p. 88
Location	Chinchilla district, Queensland; 26°43'S, 150°36'E
Altitude	300 m
Physiography	Gently undulating plain; gilgai microrelief with mounds up to 20 m across, 1 m high; shelves 6 m across
Drainage	Very poorly drained
Parent material	Clays overlying and probably from siltstone of Jurassic Walloon Coal Measures
Vegetation	Cleared from brigalow forest
Climate	Monsoon subtropical; Sm; 650 mm rainfall

Profile description

A	**0-5 cm**	Dark greyish brown (10YR 4.5/2, 5/2 dry) and greyish brown (8.5YR 5/2, 4/2 dry) light medium clay; 3-mm fragile surface crust; strongly developed granular to blocky structure; very hard, loose; a few quartz grains; clear boundary.
BA	**5-20 cm**	Brown (7.5YR 4/2, 4.5/3 dry), with some dark greyish brown (9YR 3/2) channel (1 cm) fill, medium heavy clay; strongly developed coarse breaking to fine blocky structure; very hard, very firm; a few quartz grains; a few black segregations; gradual boundary.
Bw1	**20-46 cm**	Brown (7.5YR 4.5/2, 9YR 5/3 dry), with some dark greyish brown channel fill, medium heavy clay; strongly developed coarse grading to fine blocky structure; firm; a little water-worn quartz (2 mm); a few black segregations; diffuse boundary.
Bw2	**46-90 cm**	Brown (9YR 5/3, 6/2 dry) medium heavy clay; moderately developed coarse breaking to fine blocky structure; firm, slightly plastic; a little water-worn quartz; a few soft black nodules (1 mm); few reddish brown root markings; few minor slickensides; diffuse boundary.
Bw3	**90-150 cm**	Greyish brown (10YR 5/2, 6/2 dry) with occasional strong brown (7.5YR 5/8) patches, medium heavy clay; moderately developed very coarse breaking to fine angular blocky structure; slightly plastic; few soft black nodules on major slickensides; few slickensides; diffuse boundary.
BC	**150-180 cm**	Light brownish grey (10YR 6/2, 6.5/2 dry) medium heavy clay with faint coarse light olive brown (2.5Y 5/4) and brown (7.5YR 5/3) mottles; strongly developed coarse breaking to fine angular blocky structure; moderately plastic; a few specks of white (10YR 8/2) weathered siltstone; a few yellowish red (5YR 5/8) tubule tracings.

CHROMIC VERTISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—5	6.9		28	29.3	100	15.0	12	1.0	1.3			
AB	5—10	6.0		28	25.5	91	11.0	11	1.0	2.5			
Bw1	30—46	4.7		27	24.2	90	4.4	13	0.8	6.0			
Bw2	60—90	4.4		26	22.2	85	2.9	11	0.7	7.6			
BC	150—180	4.5		27	23.4	87	2.5	11	0.8	9.1			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.06	0.02		0.14		3.0		3	23	17	57	clay
AB	0.15	0.09		0.10		2.2		2	20	17	61	clay
Bw1	0.47	0.31		0.06		1.3		1	16	18	65	clay
Bw2	0.63	0.42						0	16	18	66	clay
BC	0.74	0.49						0	13	20	67	clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5						
AB	77.6	16.1	4.4	1.2	0.02	0.05	8	47	7			
BC	74.5	17.3	4.6	1.2	0.07	0.08	7	43	6			

PELLIC VERTISOL Vp

Classification	Australia: black earths. Ug 5.15
Reference	Reeve *et al.*, 1960. Profile B204, p. 32
Location	Toowoomba district, Queensland; 27°40′S, 151°47′E
Altitude	470 m
Physiography	Alluvial plain
Drainage	Poorly drained
Parent material	Basaltic alluvium
Vegetation	Grassland
Climate	Cool subtropical; Sm; 900 mm rainfall

Profile description

A	**0-8 cm**	Very dark grey (10YR 3/1) heavy clay; strongly developed granular grading to fine blocky structure; gradual boundary.
AB	**8-43 cm**	Very dark grey (10YR 3/1) heavy clay; moderately developed coarse blocky grading to granular (lenticular) structure.
Bw1	**43-71 cm**	Very dark grey (10YR 3/1) heavy clay; few carbonate nodules.
Bw2	**71-117 cm**	Very dark greyish brown and very dark brown heavy clay; diffuse boundary.
Bk	**122-163 cm**	Very dark brown (10YR 2/2) and yellowish brown heavy clay; granular lenticular) to blocky structure; small amounts of soft and nodular carbonate.
C	**163-229 cm**	Brown to strong brown (7.5YR 5/5) and greyish brown heavy clay.

PELLIC VERTISOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—8	7.4											
AB	8—43	7.7											
Bw1	43—71	8.3		72.3	68.3	93	37.0	29.4	0.9	1.0			0.1
Bw2	71—117	8.6											
Bk	117—163	8.6		57.0	57.0	100	17.9	36.0	0.8	2.3			6.8
C	163—229	8.7											

Horizon	Sol. salts		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.05	0.02	3.4					1	8	26	65	clay
AB	0.03	0.02										
Bw1	0.03	0.02	1.4					1	6	25	66	clay
Bw2	0.10	0.04										
Bk	0.18	0.07	0.45					1	8	28	63	clay
C	0.24	0.10										

Horizon										Avail. P mg %			
A										98			

EUTRIC PLANOSOL We

Classification	Australia: grey-brown podzolic soils. Db 1.42
Reference	Stace *et al.*, 1968. Profile 31A, p. 314
Location	Mount Nelson, Tasmania; 42°56′S, 147°20′E
Altitude	350 m
Physiography	Broad crest of gentle north-facing slope, frequent rock outcrops
Drainage	Impeded by clay horizon; some seepage in weathered rock
Parent material	Jurassic dolerite
Vegetation	Sclerophyll woodland
Climate	Cool marine; Um; 635 mm rainfall

Profile description

A	0-6 cm	Greyish brown (2.5Y 5/2) sandy loam; medium crumb structure; friable; occasional dolerite fragments throughout profile; diffuse boundary.
E	6-12 cm	Light brownish grey (2.5Y 6/2) sandy loam; diffuse boundary.
EB	12-17 cm	Light brownish grey (2.5Y 6/2) gritty sand; massive; very slightly compact; slightly vesicular; occasional ferruginous concretions.
Bt	17-27 cm	Brown to dark brown (10YR 4/3) clay, faintly mottled yellower and browner; fine to coarse subangular blocky structure; firm, plastic.
BC	27-36 cm	Brown to dark brown (10YR 4/3) clay; gritty weathered dolerite.
C	55-70 cm	Yellowish brown gritty weathered dolerite with clay; rather compact.

EUTRIC PLANOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—7	5.7			7.5		4.6	2.4	0.2	0.3			
E	7—12	5.9			4.1		2.4	1.4	0.1	0.2			
EB	12—18	6.2			3.9		2.2	1.5	0.1	0.1			
Bt	18—27	6.5			17.1		8.7	7.8	0.1	0.5			
BC	27—55	6.9											
C	55—70	7.6			20.7		9.7	9.5	0.1	1.4			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total		% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.03			0.11		4.9	11	24	55	12	9	sandy loam
E	0.01			0.05		2.1	11	23	58	12	7	sandy loam
EB	0.01			0.03		1.3	15	20	60	12	8	gritty sand
Bt	0.01			0.04		1.3	23	23	36	10	31	clay
BC	0.01						28					
C	0.01			0.01			85	64	22	7	7	dolerite/clay

SOLODIC PLANOSOL Ws

Classification	Australia: Soloths. Dy 3.42
Reference	Smith, 1947. Kojonup loam
Location	Kojonup, Western Australia; 33°50′S, 117°09′E
Altitude	310 m
Physiography	Gently undulating
Drainage	Impeded by clay horizon
Parent material	Colluvial material derived from the dissection of old lateritic plateau
Vegetation	Eucalyptus forest
Climate	Subtropical mediterranean; WWm; 560 mm rainfall

Profile description

A	**0-20 cm**	Brownish grey gritty loam.
E	**20-28 cm**	Light grey gritty clayey sand, with light greyish brown mottling.
Btn	**28-107 cm**	Yellowish brown clay with some quartz gravel.

SOLODIC PLANOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—20	6.0		12	5.4	45	3.2	1.5	0.3	0.4			
E	20—28	6.2											
Btn	28—107	7.3		15	9.8	65	1.8	5.7	0.3	2.0			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as NaCl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.20	0.01						40	34	12	14	loam
E	0.01	0.01						57	25	6	12	clayey sand
Btn	0.03	0.02						7	7	14	72	clay

CALCIC XEROSOL Xk

Classification	Australia: solonized brown soils. Gc 1.22
Reference	Northcote, 1951, p. 44, 112. Tiltao sand
Location	Coomealla district, New South Wales; 34°05′S, 142°01′E
Altitude	60 m
Physiography	Top slopes of sand ridges
Drainage	Well drained
Parent material	Recent terrestrial calcareous sands and clays resorted by aeolian activity
Vegetation	Dry savanna scrub
Climate	Subtropical mediterranean; Wl; 270 mm rainfall

Profile description

A	**0-20 cm**	Brown sand; loose.
AB	**20-51 cm**	Lighter brown sand; loose; traces of lime.
Bk1	**51-81 cm**	Dusty brown to dull light brown sand; fleckings of lime.
Bk2	**81-107 cm**	Light brown loamy sand; concretionary lime nodules.
Bk3	**107-152 cm**	Light brown sand to sandy loam; lime, weakly cemented.
C	**152-300+**	Light brown to light yellowish brown sand; variable amounts of lime and lime rubble, stratified.

CALCIC XEROSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—20	9.0											0.5
AB	20—50	9.2											2.9
Bk1	50—75	9.2											5.8
Bk2	75—108	9.1			16.9		11.0	4.1	0.8	1.0			17.8
Bk3	109—170	9.2											21.0

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total	Cl as Nacl	% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.04	0.01		0.03				41	46	3	10	sand
AB	0.04	0.01						42	44	5	9	sand
Bk1	0.12	0.06						37	44	6	13	loamy sand
Bk2	0.31	0.14						32	41	10	17	loamy sand
Bk3								31	38	10	21	sandy loam

Horizon										P %			
A										0.013			

HAPLIC YERMOSOL Yh

Classification	Australia: red and brown hardpan soils. Um 5.3
Reference	Stace, 1968. Profile 9A, p. 78
Location	Wiluna, Western Australia; 26°28′S, 119°47′E
Altitude	520 m
Physiography	An extensive flat tableland
Drainage	Impeded by pan
Parent material	Not known
Vegetation	Shrub woodland and grassland
Climate	Hot subtropical desert; AZS; 250 mm rainfall

Profile description

A	**0-5 cm**	Red (2.5YR 4/6) sandy loam; friable; slightly compact; vesicular; some gravel; dark ferruginous stones on the surface; diffuse boundary.
BA	**5-25 cm**	Red (10R 4/6) sandy loam to sandy clay loam; friable, slightly compact; vesicular; some gravel; clear boundary.
B	**25-41 cm**	Dark red (2.5YR 3/6) sandy clay loam; weakly developed crumb structure; friable, slightly compact; clear boundary.
BCmq	**41-48 cm**	Red-brown with black stains; pan; hard, brittle; laminated; vesicular, walls of the vesicles coated with shiny secondary silica.

HAPLIC YERMOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									CaCO$_3$ %
		H$_2$O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—5	5.4			1.4		0.5	0.3	0.5	0.1			
BA	5—25	4.7											
B	25—41	5.1											
BCmq	41—48	5.9			2.1		0.8	0.9	0.2	0.2			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total		% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0.02			0.04		0.45	23	38	38	9	15	sandy loam
BA	0.02						27	32	41	6	21	sandy loam to sandy clay loam
B	0.02			0.03		0.19	25	31	44	9	16	sandy clay loam
BCmq	0.02							54	27	11	8	pan

LUVIC YERMOSOL Yl

Classification	Australia: calcareous red earths. Gn 2.12
Reference	Stace, 1968. Profile 24F, p. 262. Yamba family
Location	Alice Springs, Northern Territory; 23°29'S, 133°50'E
Altitude	730 m
Physiography	A small nearly flat terrace on a midslope of a broad gently undulating plain
Drainage	Well drained
Parent material	Water transported sediments from gneissic and other metamorphic rocks
Vegetation	Mulga scrub
Climate	Hot subtropical desert; AZS; 250 mm rainfall

Profile description

A	**0-11 cm**	Dark red (1.5YR 3/6, 2.5YR 4/6 dry) sandy clay loam; massive; slightly hard; porous; some 1-cm termite channels; gradual boundary.
AB	**11-38 cm**	Dark red (10R 3.6, 2.5YR 4/6 dry) sandy clay; massive; slightly hard, friable; porous; gradual boundary.
BA	**43-84 cm**	Dark red (10R 3/6, 3.5/6 dry) light clay; weakly developed medium prismatic structure; hard, friable; gradual boundary.
Bt1	**84-127 cm**	Dark red (10R 3/6) medium clay; moderately developed medium prismatic structure; friable; well-developed clayskins on ped faces; gradual boundary.
Bt2	**127-168 cm**	Dark red (10R 3/6) medium heavy clay; strongly developed medium angular blocky structure; firm; well-developed clayskins on ped faces; a few weathered gneissic 5-mm gravels.
BC	**168-178 cm**	Dusky red (10R 3/4) heavy clay, with pockets of brown to dark brown (10YR 4.5/3) gritty clay.

LUVIC YERMOSOL

Australia

Horizon	Depth cm	pH		Cation exchange me %									$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na			
A	0—11	6.0		9	5.5	61	3.4	1.1	0.3	0.7			
AB	11—38	6.4		6	4.6	77	3.0	0.8	0.3	0.5			
Bt1	84—127	7.4		14	11.8	84	5.9	4.3	0.4	1.2			
BC	168—178	7.5		12	12.0	100	5.9	4.7	0.3	1.1			

Horizon	Sol. salts %		Organic matter				Particle size analysis %					
	Total		% C	% N	C/N	% OM	Stones	Coarse sand	Fine sand	Silt	Clay	Texture
A	0			0.05				41	32	7	20	sandy clay loam
AB	0.01			0.03				41	27	5	27	sandy clay
Bt1	0.01			0.02				21	20	11	48	clay
BC	0.02						11	35	16	8	41	clay

Horizon	Silicate analysis %						$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{SiO_2}{R_2O_3}$			
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	P_2O_5						
A	82.1	10.0	3.6	0.5	0.03	0.08	14	61	11			
Bt1	67.7	19.5	7.0	0.7	0.01	0.08	6	26	5			

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