Part 1

PHYSICAL ENVIRONMENT

Soils of Victoria

Introduction

The main interest in a soil lies in its ability to grow plants. Soils differ among themselves in many respects : in their chemistry, their relations to air and water, their degree of slope, and their stoniness. Superposed on these differences are the differences in climate, or in access to water, that commonly limit the use of the land. These various properties will first be discussed with illustrations derived from the coloured map, which is described in more detail later.

Chemistry

Phosphorus

The element of most interest in Australia is phosphorus. Victoria is typical of Australia in its general poverty in phosphorus. Whether the parent material is wind-borne or water-borne, sedimentary or igneous, granitic or basaltic, whether the climate is dry or wet, the story is generally the same—a natural total supply of about 200 parts per million of phosphorus in the surface soil, and less in the subsoil. The sandier soils have less than this again. In Great Britain, on the other hand, three times this figure would be thought ordinary. The exceptional areas in Victoria with a good natural supply are of small extent, though they have won a local reputation ; most of them are formed either on young alluvial deposits, too recent to have been leached by the rain, or on patches of volcanic tuff within a few miles of a volcanic cone, which again is young.

It is not surprising that superphosphate has twice been a decisive material in Victoria's agricultural history. It was applied to wheat in the early years of the century after the yield had fallen to below 10 bushels per acre even in the good climate of the Wimmera, and was so successful that it was universally used before many years had passed. Thirty years later, it was used as top-dressing on pastures, to bring in the European clovers and high-grade grasses to replace the native grasses that were adapted to poverty. These pastures were established in the dairying and meat-producing land both of the south and of the irrigated north.

Most of the meagre total of the original phosphorus was tightly bound to the soil and could dissolve only very slowly. Very small additions of soluble phosphate therefore caused a spectacular increase in growth. These additions in the early years were especially successful since they were sown in the same row as the seed, and thus unwittingly the Australian wheat farmers used their fertilizer in the cheapest and most efficient way, which was not adopted overseas for another 40 years.

It seems likely that a store of fairly high-grade phosphorus is being built up from the residues of fertilizer, especially in the pastures, which are treated more generously than wheat crops. Thus, a hundredweight of superphosphate containing 11 lb. of phosphorus can make up for the element removed in 27 fat lambs or 75 bushels of wheat. Few of Victoria's soils seem to degrade this added phosphate rapidly ; it may take decades or centuries before the residues become as useless as the original reserves.

Acidity and Alkalinity

The general experience of the world is that the higher the rainfall the lower are the reserves of chemical wealth in a soil, and this relation is shown by the pH* of the soil, both at the surface and in the subsoil.

The main climates in Victoria range from the warm semi-desert of the north-west through the mild and wet coastal hills of Gippsland to the colder and wetter mountains of the north-east. The cooler and wetter regions have acidic soils with 5·5 a common value. The acidic soils extend well north of the Divide, including most of the hilly country with 20 inches or more of annual rainfall. On the other hand, less acidic soils with a calcareous subsoil occur in the south in the drier areas to the west of Melbourne and near Sale in Gippsland (parts of Landscapes 7 and 11). The warmer and drier north has alkaline soils, reaching an extreme in the Mallee where a pH above 9 is the rule in the subsoil and is frequent even at the surface. Little has been done to change the pH in either direction except in some horticultural areas.

Potassium

The reserves of potassium in Victorian soils follow the usual rule. In the north, where soils are alkaline and the rain is light, they are generally high. The wheat belt has never needed potassium fertilizer. In the south, where soils are acid, reserves are generally low, except in the dry belts to the west of Melbourne and near Sale. But this again must be qualified in the usual way, since it is mostly the sandy and not the clayey soils that have the low reserves. At the same time, even among clayey soils some deep red soils on basalt have shown potassium deficiency ; the kaolinitic clay of these soils has a low retaining power for metals.

Where potassium is shown to be seriously deficient, it is mostly on pastures, where clover is the first to suffer. As a rule, it is the outer paddocks of a dairy farm that show the trouble, or any paddock that has often been cropped for hay.

Potassium fertilizers are being used in increasing amounts in the south, though still not sufficiently to make good the natural poverty and the slow depletion with commercial farming.

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* The pH scale is a measure of acidity and alkalinity, a value of 7 being neutral. Any value below 5 is strongly acid and any value above 9 is strongly alkaline.

Organic Matter and Nitrogen

These go together, since the soil's reserves of nitrogen are in organic combination, making an average of one-twentieth of the total organic matter. The total native supply of nitrogen varies with the climate and texture and the reserve of other elements, especially phosphorus. Thus 0·05 per cent. in the Mallee, 0·10 per cent. in the Wimmera, 0·15 per cent. in the Western District, and 0·25 per cent. in Gippsland are representative figures, but within any one of these climatic zones there is a large range. Under heavy forests in the wetter hills, as at Mount Dandenong, the organic content reaches 10 per cent.

These values have moved both upwards and downwards since the land was occupied. The main decreases have been on wheat farms where crop has alternated with a year of bare fallow for 30 years or more. The main increases have been where high-grade pastures have been established. In some places, as at the State farm at Rutherglen, both effects have been shown in a spectacular way ; an early decline with overcropping, and a recovery under pasture to exceed the original level.

The practical interest of nitrogen is in its current supply, not in the total amount. The northern soils, in spite of their lower total, are so managed as to give a better supply of nitrogen than the southern soils. Nitrogen fertilizers are still little used through the State, except for a few special crops. In most parts, the clovers, by fixing atmospheric nitrogen, make additional fertilizers unnecessary for the major crop—namely, grass. The next biggest crop—wheat—is sown after a period of grazing during which leguminous plants have contributed fixed nitrogen, or (less generally nowadays) after a spring and summer of fallow during which ample nitrate has been able to accumulate.

Trace Elements

Those needed by plants to the extent of a few parts per million have become well known through their use in South Australia and Western Australia, in transforming poor country into good. These elements are not so widely deficient in Victoria, but their use has shown some spectacular successes, won almost entirely by trial and error.

Molybdenum appears to be the most important of these, and has been especially needed as an addition to superphosphate in order to establish subterranean clover (the first step in improving the naturally poor country). The deficient soils have been found especially on the upper slopes of the foothills of the main Dividing Range (Landscape 6), but they are widespread elsewhere. They are acidic, with pH 5 to 6, and many of them are gravelly loams, grey or brownish grey. The underlying rock may belong to a range of sedimentary or igneous types. Two ounces of molybdenum oxide to an acre has been effective for several years.

Zinc has been used successfully both in the Mallee and in the Wimmera in increasing the growth of crops on the common calcareous soils of those districts. In the Wimmera it has been used with superphosphate on wheat (Landscape 21) and in the Mallee it has been most used on the irrigated vines (Landscape 23).

Copper deficiency has appeared mostly on some very sandy soils (mostly of Landscape 13) in the far Western District and in eastern Gippsland. A double deficiency of copper and zinc occurs in some deep sands further inland, lying in areas traditionally known as " Big Desert " and " Little Desert ", on the South Australian border (Landscapes 13 and 25).

Manganese deficiency is rare, and has appeared mostly where naturally acidic soils have been made alkaline by liming in the vegetable-growing area to the east of Melbourne. At the other extreme some of the irrigated orchard soils of the north have been so much acidified by ammonium sulphate that manganese has dissolved from reserves in the soil in amounts that damage the trees. The total manganese in the soil is irrelevant to both of these problems. As with so much of soil chemistry, the interesting question is : What is the state and amount of the small reactive fraction ?

The general impression, then, is one of widespread original poverty of soil which is gradually being made good. The only general explanation of this can be that many of the soils are so old that there has been ample opportunity for the necessary elements to be lost in drainage water since the soils began to form. How far geological poverty is responsible is more debatable.

Salt

Sodium chloride, with some other soluble salts, has accumulated in many soils where the annual rainfall is below 30 inches. Throughout the south and in much of the north this salt must have been brought in by the rain over the centuries. Southerly storms are high in salt ; the coastal districts receive 50–100 lb. of sodium chloride per acre each year. In the drier part of the north (including the Mallee) the salt may have had other origins.

This salt has caused trouble in various regions. In the former gold-mining country just north of the Divide (especially Landscape 6), salt has accumulated on lower slopes as a consequence of clearing the timber at higher levels, so making the soil climate wetter and allowing salt soaks to appear. Some of these have killed the native cover and led to erosion. Many subsoils are strongly saline in the drier parts of southern Victoria with rainfall below 25 inches. The large Lake Corangamite, draining basaltic country, is almost as saline as the sea. Even with rainfalls as high as 30 inches, small salt patches still appear at the foot of slopes, at points where the downward movement of ground-water is checked. Underground water in many parts of the State is also so saline as to be unusable except for sheep to drink.

Salt is a constant danger in the irrigated areas wherever the rainfall is below 17 inches. Many properties have been ruined by the concentration of salt close to the surface by irrigation, coming from the native reserves at 3 feet deep. This danger is being met with some success nowadays, with better layout of irrigated land, under-drainage and care in not using more water than is needed.

Physical Properties

Excluding some of the hilly or mountainous parts of the State, where the steepness prevents ordinary settlement, the main physical impediments in the soil are stone and poor drainage.

Poor drainage is the most serious natural defect of many soils. A few major areas of swamp have been reclaimed with large canals. The biggest of these, the former Koo-Wee-Rup Swamp at the head of Westernport Bay (Landscape 16), covers 80 square miles of which about half is peaty clay; this land is densely settled for dairying and cropping. But apart from such ambitious schemes, there are large areas in the State where the country is too wet in winter and early spring. This is especially true of the heavier of the many soils on basalt, and the " duplex " soils (see below) of the south and the better watered north. While the heavier soils are being improved by surface drainage, the duplex soils need under-drainage. Tile drainage is needed and partly supplied in the irrigated land of the north, but this is not a problem of peculiar soils.

Large areas of very sandy soils have been left uncleared. Until recent years, it was not realized that their chemical defects could be made good, and their liability to drought is discouraging except where the rainfall is generous. Deep sands occur in patches along the coast (Landscapes 13 and 15), and spread inland to the greatest extent in the far west.

Soil Maps

General

The Commonwealth Scientific and Industrial Research Organization, the Victorian Department of Agriculture, the Soil Conservation Authority of Victoria, and the School of Agriculture, University of Melbourne, have worked in mapping the soils of parts of the State. The unit of detailed mapping is the *soil series* or the *soil type*, in which are included all soils in which the whole vertical section or profile, down to a depth of 6 feet as a rule, follows the same sequence, under a name such as Cobram sandy loam (a type favoured for irrigated horticulture). Maps of soil types are commonly published on a scale of 2 inches or more to the mile. For larger areas, on a smaller scale, the *soil association* is used as the mapping unit, this being the pattern of three or four soil types that may be repeated several times over one kind of landscape.

The detailed mapping by Commonwealth and State authorities has been concentrated in the irrigated areas, where farmers' holdings are small and detailed information is most valuable, especially where fruit trees and grape vines are concerned. Such maps are now made before the irrigated area is settled, and are used for deciding which land to open up and for what activity. Of the 1,000 square miles of which detailed soil maps have been published by government bodies up to 1962, most cover irrigable country.

Besides these, maps have been published on a broader scale on unirrigated country, including two of land where erosion is a danger (Coleraine in the Western District, and Dookie in the hilly part of the

Northern District). These may be grouped with the soil-and-land-use survey around Berwick (25 miles east of Melbourne) carried out by the School of Agriculture at Melbourne University, as samples of " spot surveys ". If a small area, which shows some of the complexity of a much larger area, is intensively studied, one who knows this detail should then understand the larger areas fairly well. On a broader scale, again at 4 miles to an inch, a map of " land units " has been produced by soil workers in pioneering country in the far west of the State.

Soil Map of Victoria

The coloured soil map of Victoria, which accompanies this chapter, has been prepared from the Atlas of Australian Soils, published by C.S.I.R.O. in association with Melbourne University Press after some simplification. On this scale of one to two million, one cannot show individual soil types, or even associations. Instead, the units here are *landscapes*, areas of country with a similar pattern of land. Obvious examples of these are the mountainous country (Nos. 1 and 2), coastal sand dunes (some of 15), and the flat Goulburn Valley (9). Each landscape is represented on the map by its dominant soil. Other soils besides the dominant one are bound to make up part of the landscape. Some of those occupying a small proportion of an area may be practically important, like valley alluvium in hilly country. Such patches cannot be marked on the map, which has to be kept simple, but they are mentioned in the booklets which accompany the Atlas of Australian Soils, Sheets 1 and 2.

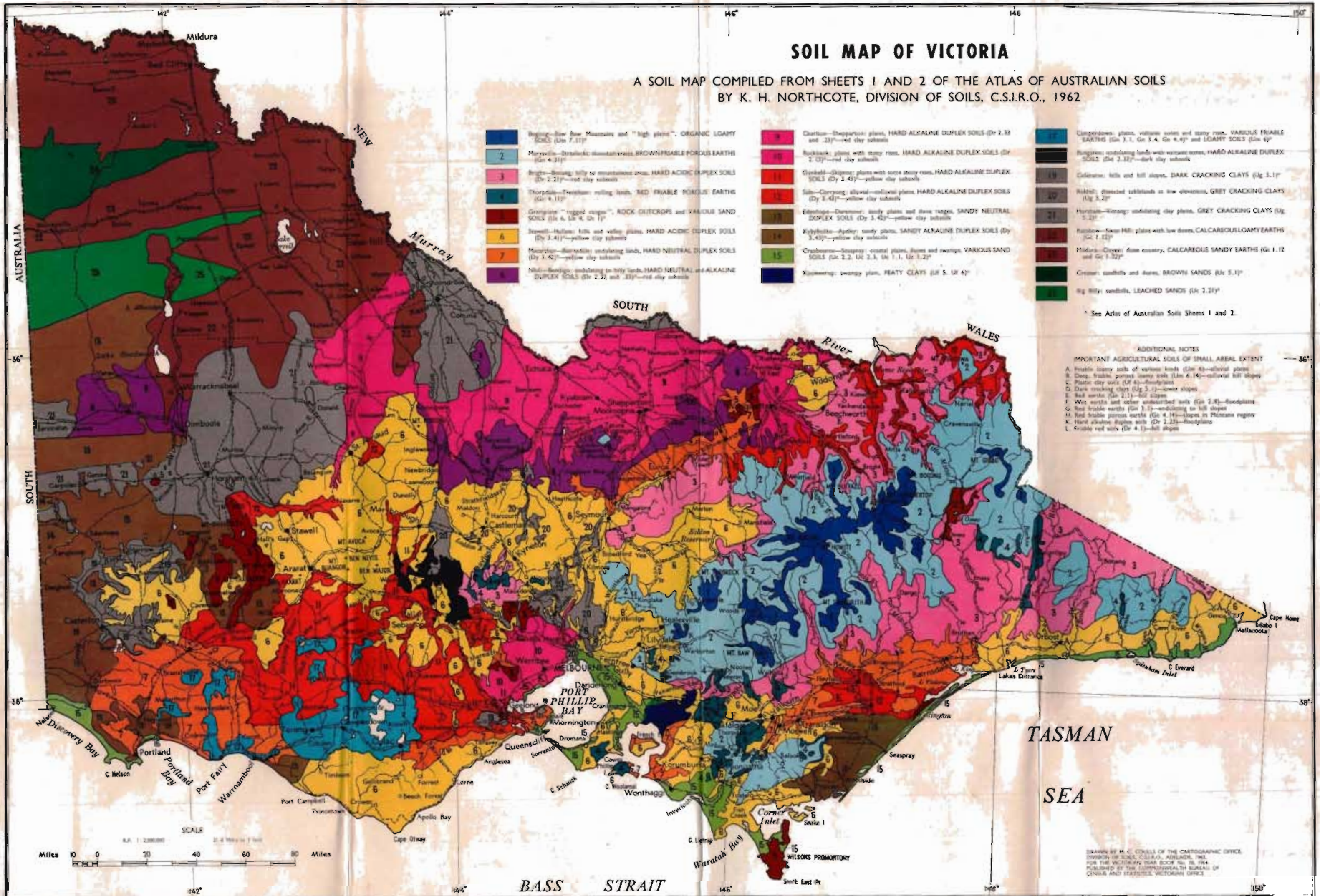
The 25 dominant soils of the map are distinguished from each other, in the first place, by the physical skeleton of the top 3 or 4 feet, whether of uniform texture (first letter U, sandy throughout Uc, loamy throughout Um, clayey throughout Uf or Ug) ; with a gradual change towards more clay with depth (first letter G) ; or with a sudden change from a sandy or loamy surface to a clayey subsoil, here called duplex (first letter D). As the key shows, a distinction is also made according to acidity, neutrality and alkalinity, and according to colour of subsoil. For further explanation of these and of the decimal system the reader is referred to the letterpress accompanying the Atlas. The confused names given to soils overseas have been avoided in this Atlas and in this account.

When soils are mapped on such a generalized scale, individual opinions are likely to differ on whether a certain area should be lumped in with this or that kind of country. Such differences cannot be solved. The boundaries as given here are slightly simplified as compared with those in the Atlas sheets.

Major Landscape Units

Some of the major landscape units are now discussed in turn.

The Mallee has two agricultural areas, No. 22 in the south, and No. 23 in the drier north-west. Alkaline sandy loam, passing gradually with depth to a more alkaline sandy clay loam or sandy clay, is common to both, but more sandy soils are more frequent towards the north-west. Lime occurs in the subsoil, whether soft and finely divided, or as hard,



SOIL MAP OF VICTORIA
A SOIL MAP COMPILED FROM SHEETS 1 AND 2 OF THE ATLAS OF AUSTRALIAN SOILS
BY K. H. NORTHCOTE, DIVISION OF SOILS, C.S.I.R.O., 1962
ORGANIC LOAMY SOILS
BROWN FRIABLE POROUS EARTHS
HARD ACIDIC DUPLEX SOILS
RED FRIABLE POROUS EARTHS
ROCK OUTCROPS and VARIOUS SAND SOILS
HARD ACIDIC DUPLEX SOILS
HARD NEUTRAL DUPLEX SOILS
HARD NEUTRAL and ALKALINE DUPLEX SOILS
HARD ALKALINE DUPLEX SOILS
HARD ALKALINE DUPLEX SOILS
HARD ALKALINE DUPLEX SOILS
HARD ALKALINE DUPLEX SOILS
SANDY NEUTRAL DUPLEX SOILS
SANDY ALKALINE DUPLEX SOILS
VARIOUS SAND SOILS
PEATY CLAYS
VARIOUS FRIABLE EARTHS and LOAMY SOILS
HARD ALKALINE DUPLEX SOILS
DARK CRACKING CLAYS
GREY CRACKING CLAYS
GREY CRACKING CLAYS
CALCAREOUS LOAMY EARTHS
CALCAREOUS SANDY EARTHS
BROWN SANDS
LEACHED SANDS
* See Atlas of Australian Soils Sheets 1 and 2.
ADDITIONAL NOTES
IMPORTANT AGRICULTURAL SOILS OF SMALL AREAL EXTENT
Mildura
NEW
SOUTH
WALES
Murray
River
SOUTH
AUSTRALIA
Echuca
Shepparton
Wodonga
Beechworth
Warracknabeal
Dimboola
Horsham
Stawell
Ararat
Castlemaine
Kyneton
Seymour
Healesville
Lilydale
MELBOURNE
PORT
PHILLIP
BAY
Geelong
Mornington
Dromana
Queenscliff
Sorrento
Anglesea
Lorne
Apollo Bay
Cape Otway
Port Campbell
Warrnambool
Port Fairy
Portland
Portland
Bay
Discovery Bay
C Nelson
Wonthaggi
Inverloch
Corner
Inlet
WILSONS PROMONTORY
South East Pt
Waratah Bay
C Liptrap
Seaspray
L Tyers
Lakes Entrance
C Everard
Mallacoota
Gabo I
Cape Howe
TASMAN
SEA
BASS
STRAIT
SCALE
Miles
Miles
142°
144°
146°
148°
150°
36°
38°

pebbly concretions. The soils are derived from wind-blown materials consisting of quartz with calcareous clay, with a remarkable absence of particles in the silty range of 0·02 to 0·002 mm. The dunes that were thus formed in an arid period persist in a fixed state in the present wetter climate. The pink to red-brown colour of the quartz grains is superficial and can easily be washed off by acid ; it has been called " desert varnish ". These soils are commonly somewhat saline. The various " mallee " species of eucalypts roughly coincide with the Mallee Statistical District, with the dry side of the 15-in. rainfall line, and with the dominance of these sandy loams, which in some books and articles are called " mallee soils " and " mallisols ".

To the west are two areas of pure sand (24, 25) without the useful admixture of a little clay which helps the occupied area both physically and chemically. The " Big Desert ", No. 25, has lower and less reliable rainfall than the former " Ninety-mile Desert " of South Australia, so that no attempt has been made to cure its similar chemical poverty.

The soils that give the Wimmera its reputation for wheat growing are mapped as 21. These are deep grey calcareous clays, often spoken of as " black ". They swell on wetting and crack deeply on drying. The surface forms small, loose crumbs on drying, and is called " self-mulching ". On uncultivated land the swelling and cracking leads to a surface pattern of puffs and depressions, to which the aboriginal name of gilgai is given (hence the code letter Ug). Of all soils in the State, these have undergone the longest period of exploitation of their original reserves of nitrogen, and the protein in the wheat grain has fallen to 8–9 per cent. With the present trend to grazing with leguminous species, the protein figure is rising again. The calcareous clays are uniform over large expanses, and in places alternate in a complex mosaic with red-brown loams of duplex profile which are physically much less attractive.

The flat riverine plain, in which the lower Goulburn Valley (Landscape 9) takes a major place, and much of which is irrigated, occupies much of the Northern District and some of the adjoining districts. There is a wide variety of textures related to earlier river systems, from sand in former channels to clay in former flood-plains. The commonest soils are neutral silty loams overlying alkaline clays. Under irrigation the fine silty texture leads to very slow rates of infiltration by water.

The mountainous country of the north-east (Landscape 2) is dominated by brown loams with friable and permeable subsoils, which are well adapted for carrying their eucalypt forests and for conserving water from the heavy rainfall. At higher levels (roughly 4,000 feet), and especially on the " high plains " (Landscape 1), soils of higher organic content are common.

The foothills of the Divide, and many other areas of sloping land with a rainfall between 20 and 30 inches, carry " duplex " soils, very different from the soils of the mountains. The most striking examples are in the zone marked 6, where a permeable surface of grey sandy loam or silty loam or gravelly loam overlies an impermeable yellow-grey clay at a depth of 1 to 2 feet, with a sudden transition from loam to clay. The sub-surface is pale above the clay, and usually a layer of ironstone gravel occurs at this junction. These duplex soils occur on both granite, tertiary sediment, and Palaeozoic sedimentary rocks. During the wet periods in winter and spring, these soils become saturated down to the level of the clay. Below the immediate surface, where living and decomposing roots help to consolidate it, the sub-surface becomes semi-fluid. (This waterlogging is responsible for the chemical movement of iron into the gravel over the centuries and the consequent bleaching of the surrounding soil). Tunnel erosion, which is described below, is characteristic of these soils. Excess salt is also a common problem.

In spite of their unpromising appearance either under their native eucalypt cover or under native grasses after clearing the trees, these soils grow first-class pastures after the usual treatment of superphosphate with subterranean clover. In many places molybdenum also is needed before the clover will grow well. The worst defect of the soils is poor drainage.

There is much debate on how the same parent materials have given rise to such different soils as those here described and the more attractive, permeable soils of the mountains. One possibility is that under the rainfall of the coastal districts the sodium chloride of the rain has introduced enough sodium into the clay to make it more easily dispersible than normal, while under the higher rainfall in the mountains the salt has always been too dilute to do this. The names *yellow podzolic* and *solodic* have been given elsewhere to these duplex soils.

Soils on Basalt

Basalt of Pliocene and Pleistocene age (marked on geological maps as " Newer " basalt) is the major rock in southern Victoria from Melbourne to the South Australian border. The area of basaltic country is 9,000 square miles ; there are wide sheets of lava and centres of explosion dating up to historic times. The variety of soils is very great, both in colour (red, grey, and black), in texture (friable loams, easily permeable clays, hard impermeable clays and clay loams), in degree of contrast between upper and lower horizons, in acidity and alkalinity, and in stoniness. The popular concept of " volcanic soil ", as a deep friable red soil with the parent rock far below the surface, corresponds to Landscape 4, which is best found on the much older basalts of the Gippsland hills ; but this holds only a minor place in western Victoria, namely near Trentham on the Divide.

Landscape 17, including Colac and Camperdown, has been marked for the number of young volcanic cones from which has come the covering of fine tuff over the surrounding country. Small farms growing potatoes and onions as well as dairying are concentrated around the cones (which, of course, occur on other landscapes besides this). Even within this favoured area, however, stony and clayey country developed from the lava flows is widespread.

Landscapes 7, 10, 11, 18, and 20 include the naturally less attractive soils on basalt and many of the large pastoral holdings. One common pattern (especially in 20, also in 10) is of " stony rise " country, with outcrops of solid rock carrying little soil, and the lower slopes and flats carrying tough clay with an alkaline subsoil of very heavy clay. The most interesting departure from this soil is the crumbly black soil ringing the foot of the stony rises. A similar crumbly soil occurs elsewhere on creek banks, where additional calcium bicarbonate enters in the seepage from the basalt above. Patches of gilgai are common features on the flats in this kind of country.

On some of the older flows the clay has weathered further to a kaolinitic type which does not swell and crack much (especially in Landscape 11). The soil of this older land often contains copious ferruginous concretions of pea size, locally called " buckshot ". This country is chemically the poorest of the basaltic areas, though capable of improvement with phosphatic fertilizing like the rest of the State.

Soil Erosion

Erosion by wind has done some damage in parts of the Mallee, with its dry climate and sandy soils, where land is left under bare fallow in the season before the wheat is sown. The high dust clouds which reach the coastal towns in some dry seasons, and which sometimes precipitate as red rain, have come from the Mallee and from further inland. The shifting sand is a nuisance within the district, where it obstructs fences, roads, railways, and water channels.

Erosion by water is worst on the poor grazing land of the northern slopes of the Divide, where the rainfall averages 20 to 25 inches, where the seasonal contrasts of rain and drought are more severe than in the south, and where introduced pastures have hardly yet appeared (Landscape 6). In general, Victoria is fortunate in having more gentle rain than the northern States, but torrential rain falling on bare land in the warmer months is still frequent enough to be a danger, especially in the north-east.

The common forms of erosion—sheet and gully—may be seen in most of this northern foothill country. But the most widespread form of erosion by water is tunnelling, which is a particularly Victorian problem. Tunnelling is characteristic of certain soils rather than of climates, namely the duplex soils especially found in Landscapes 6 and 8. The erosion of these susceptible soils begins in the semi-fluid layer just above the clay subsoil ; at those points where excessive water soaks through the permeable top foot and is checked at the clay, an underground stream of mud is created and this appears as a mud spring lower down the slope. The tunnel enlarges till at last the surface soil collapses, forming a succession of potholes. A whole hillside may be thus undermined. Like the more obvious forms of sheet erosion, this also starts with overgrazing whether by sheep or rabbits, resulting in the exposure of a hard surface on which few plants can establish themselves, and from which rain runs off, to collect in excessive quantity at points where it happens to be checked long enough to soak in. The feature of hard setting, mentioned in the legend for many of these soils, is important in this connection.

Soil erosion was brought increasingly into public notice during the late 1930's. The Soil Conservation Authority of Victoria (constituted in that form in 1950) is officially concerned with preventing erosion. Simply improving the land with subterranean clover and superphosphate has played a big part by providing more cover. The destruction of rabbits by myxomatosis in 1950–51 and their suppression since then have also helped immensely. By working on the contour, and contour ripping or furrowing of pastures, the landholder can check the flow of water downhill. At the same time in the Mallee, a bigger proportion of sandhill country is being grazed and not cropped, and there, too, the situation has become less alarming. In both the drier and the wetter regions, farmers have been prosperous enough in post-wars years to apply the principles which conservationists have arrived at.

Geographical Features

Introduction

Australia is situated in middle and lower-middle latitudes, with about two-fifths of its area lying between the Tropic of Capricorn and the Equator. It is, therefore, one of the warm continents and, since most of its area lies within the zone of the dry, sub-tropical anti-cyclones (" the horse latitudes "), it is for the most part a dry continent. Much of the continent has only small variation in temperature from season to season and receives low rainfall with marked concentration into either summer (in the north) or winter (in the south).

Victoria is, in these respects, not typically Australian. It has a cool to cold winter, and although there are hot periods in each summer, they are interspersed with pleasantly warm or even cool periods. Rainfalls are rather low in the northern parts of the State, and particularly in the north-west, but the greater part is well watered with no marked seasonal concentration. Most of Australia is plateau or plain country with little relief; Victoria has a larger proportion of high country in its total area than any other State except Tasmania and its highest mountains reach over 6,000 feet above sea level. Not surprisingly, it could be called the " most English " part of the mainland, although a closer climatic and agricultural analogy is probably south-western and south-central France. Victoria is in fact transitional between the sub-tropical situation of New South Wales and the temperate situation of Tasmania, between the high rainfall character of the south-eastern Australian coastlands and the arid interior. One finds, then, year-round, open-air dairying and livestock-and-grass farming in Gippsland and the Western District, and dry-farming of grains and irrigated horticulture of citrus fruits and vineyards in the north. Its climatic conditions made no difficulties for the establishment of secondary industry and, once its power resource problem had been solved, Victoria reaped the advantages in interstate trade offered by its central position on coastal shipping routes.

Victoria has 2·96 per cent. of the area of Australia (mainland Australia and Tasmania, but not including external territories) and had 27·94 per cent. of the Australian population at 30th June, 1962.

In relating population to area, Victoria is the most densely populated of the States with an average density at 30th June, 1962, of 34·04 persons per square mile and is exceeded only by the Australian Capital Territory (69·96 per square mile).

The Victorian population is growing rapidly; comparing the enumerated population of the Census of 30th June, 1954, with the estimate of 30th June, 1962, the population of Victoria increased by 21·98 per cent., being exceeded by South Australia (24·12 per cent.), the Australian Capital Territory (116·70 per cent.), and the Northern Territory (68·74 per cent.).

The distribution of population over the State, however, is very uneven. At the 30th June, 1962, it is estimated that 65 per cent. of the total population of the State was living in the Melbourne Metropolitan Area, a larger concentration of population into the metropolis than was to be found in any other State of the Commonwealth. On the other hand, there are considerable areas of Victoria which are uninhabited or have only a very sparse and seasonal population; these areas are mainly in the Eastern Highlands and in the western and north-western parts of the State along the South Australian border, as in the Mallee, where sandy soils and low, unreliable rainfalls inhibit agriculture. The non-metropolitan population is fairly evenly divided between the rural population (15 per cent. of the State's total in 1961) and the urban centres other than Melbourne (20 per cent. of the total in 1961). Both percentages refer to the Census of 1961.

In the rural areas, population is densest in the irrigation areas, in the dairying areas of Gippsland and the Western District, and in the livestock-and-crop farming areas between Ballarat and Bendigo. Lower densities are found in the wheat-farming areas of the Wimmera, and still lower densities in the wheat areas of the Mallee and in the stock-raising areas generally.

Among the non-metropolitan cities four large centres stand out : these are Geelong (estimated population at 30th June, 1962, 94,350), Ballarat (55,670) and Bendigo (40,980), each of which has a variety of manufacturing industries as well as being marketing and transport centres, and the Latrobe Valley group of towns which together contain about 50,000 people and are mainly concerned with power generation and distribution. The next group, in order of population size, has between 12,000 and 16,000 people each and contains, in addition to the normal urban retail and service functions, fairly large-scale industries processing local products: Warrnambool (dairy products, textiles and clothing), Shepparton (fruit canneries), Wangaratta (a rather special case of decentralized industries) and Mildura (fruit and vegetable packing). Next, there are a number of regional urban centres of between 7,000 and 10,000 people in which retail and service functions predominate; for instance, Hamilton, Colac, Horsham, Benalla, Ararat, Sale, Wodonga, Bairnsdale, Maryborough and Castlemaine. Smaller towns serve more restricted areas and more local requirements.

Although European settlement in Victoria is little over one and a quarter centuries old, there have already developed distinctive regional characteristics in the various parts of the State, and most of these are recognized in popular speech by regional names. The Mallee is the north-western plain of ancient sand ridges, once waterless and covered with the distinctive dwarf eucalypt from which the name is derived, but now with extensive wheat fields and sheep paddocks and with water for stock and domestic purposes supplied through winding channels from storages outside the region. The Wimmera, with red-brown soils and tall eucalypts, with a denser pattern of farms and market towns, has the highest yielding wheat fields in Australia and a considerable sheep and cattle population as well. The Western District, with lush pastures on its well-watered volcanic plains, has both a long tradition of the growing of fine wools on sheep stations dating back to the early days of the pastoral expansion and a much more recent development of intensive dairying. The north-east has irrigated citrus and stonefruit orchards, market gardens and pastures on the plains of the middle Murray and its tributaries, which give way to cattle stations upstream where the valleys run back into the rugged slopes of the Australian Alps. Gippsland spells dairying and fodder-crop growing, timber extraction in the tall forests of the hills, off-shore and coastal fishing, and the industrial enterprises based on the power derived from the Morwell–Yallourn brown coal deposits in the Latrobe Valley. The Port Phillip Bay region holds Melbourne, the financial and administrative hub of the State and a fast growing port, metropolitan market, and industrial centre, while on the eastern shore commuters' and holiday homes stretch through the Mornington Peninsula to the ocean shores. On the west, secondary industry is extending through Williamstown and Altona to Geelong.

Area and Boundaries

Victoria is situated at the south-eastern extremity of the Australian continent, of which it occupies about a thirty-fourth part, and contains about 87,884 square miles, or 56,245,760 acres.

Victoria is bounded on the north and north-east by New South Wales, from which it is separated by the River Murray, and by a straight line running in a south-easterly direction from a place near the head-waters of that stream, called The Springs, on Forest Hill, to Cape Howe. The total length of this boundary, following the windings of the River Murray from the South Australian border along the Victorian bank to the Indi River, thence by the Indi or River Murray to Forest Hill and thence by the straight line from Forest Hill to Cape Howe, is 1,175 miles. The length of the River Murray forming part of the boundary is approximately 1,200 miles, and of the straight line from Forest Hill to Cape Howe, 110 miles. On the west it is bounded by South Australia, on the south and south-east its shores are washed by the Southern Ocean, Bass Strait, and the Pacific Ocean. It lies approximately between the 34th and 39th parallels of south latitude and the 141st and 150th meridians of east longitude. Its greatest length from east to west is about 493 miles, its greatest breadth about 290 miles, and its extent of coastline 980 miles, including the length around Port Phillip Bay 164 miles, Western Port 90 miles, and Corner Inlet 50 miles. Great Britain, inclusive of the Isle of Man and the Channel Islands, contains 88,119 square miles, and is therefore slightly larger than Victoria.

The most southerly point of Wilson's Promontory, in latitude 39 deg. 8 min. S., longitude 146 deg. 22½ min. E., is the southernmost point of Victoria and likewise of the Australian continent; the northernmost point is where the western boundary of the State meets the Murray, latitude 34 deg. 2 min. S., longitude 140 deg. 58 min. E.; the point furthest east is Cape Howe, situated in latitude 37 deg. 31 min. S., longitude 149 deg. 59 min. E. The westerly boundary lies upon the meridian 140 deg. 58 min. E., and extends from latitude 34 deg. 2 min. S. to latitude 38 deg. 4 min. S.—a distance of 280 miles.

The following table shows the area of Victoria in relation to that of Australia :—

AREA OF AUSTRALIAN STATES

State or Territory	Area	Per cent. of Total Area
	sq. miles	
Western Australia	975,920	32·85
Queensland	667,000	22·45
Northern Territory	523,620	17·62
South Australia	380,070	12·79
New South Wales	309,433	10·42
Victoria	**87,884**	**2·96**
Tasmania	26,215	0·88
Australian Capital Territory	939	0·03
Total Australia	2,971,081	100·00

Mountain Regions

The mountainous regions of Victoria comprise the Central Highlands and a belt known as the Southern Uplands lying to the south and separated from the Central Highlands by plains.

The Central Highlands form the backbone of Victoria, tapering from a broad and high mountainous belt in the east until they disappear near the South Australian border. In the eastern sector patches of Older Volcanic rocks occur and peaks rise more than 6,000 feet, while in the western sector the volcanic rocks belong mainly to the Newer Volcanic Series and the peaks reach 3,000 feet.

The Highlands descend to plains on their southern and northern flanks. On the south are the Western District Plains and the Gippsland Plains, and beyond these again rises a group of uplifted blocks constituting the Southern Uplands. The Otway Ranges and the hills of South Gippsland are composed of fresh-water Mesozoic sediments and Tertiary sands and clays with Older Volcanic rocks in South Gippsland, and the Mornington Peninsula is an upraised fault block of complex geology, including granites.

By 1875 the mountainous areas of the State were embraced by a geodetic survey which had been started in 1856. This was the first major survey, although isolated surveys had been carried out as early as 1844. Further surveys were carried out by the Australian Survey Corps during the Second World War, and by the Department of Lands and Survey, in the post-war years. Most recent values for some of the highest mountains in Victoria are Mount Bogong, 6,516 feet; Mount Feathertop, 6,307 feet; Mount Nelse, 6,181 feet; Mount Fainter, 6,157 feet; Mount Loch, 6,152 feet; Mount Hotham, 6,101 feet; Mount Niggerhead, 6,048 feet; Mount McKay, 6,045 feet; Mount Cobboras, 6,030 feet; Mount Cope, 6,026 feet; Mount Spion Kopje, 6,025 feet; and Mount Buller, 5,919 feet.

Further Reference

An article on Victoria's Mountain Regions will be found on pages 43 to 67 of the Victorian Year Book 1962.

Coastline

The Victorian ocean coastline stretches some 682 statute miles from the South Australian border to the New South Wales border. Small stations of whalers and sealers were operating along the coast, mainly at Westernport, Portland, and Wilson's Promontory long before the advent of Henty and Batman.

The coastline is now well served with lighthouses*, though in the early days it proved hazardous to navigation and no fewer than six ships were wrecked at Port Fairy before 1850. Port Phillip Bay is a safe harbour for shipping and the cities of Geelong and Williamstown afford excellent facilities.

The main features of the coastline are as follows :—

Nelson to Cape Bridgewater	Sandy beach backed by dunes.
Cape Bridgewater to west end of Portland Bay	Cliffs of basalt tuff dune limestone and Miocene limestone.
Portland Bay to Port Fairy	Sandy beach backed by dunes with low cliffs of basalt and dune limestone near Port Fairy.

* See also pages 816 to 821.

Port Fairy to Warrnambool	Beach dunes and dune limestone.
Warrnambool to Childers Cove	Cliffs of dune limestone.
Childers Cove to Point Ronald	Bold cliffs of Tertiary limestone.
Point Ronald to Cape Volney	Cliffs of lower Tertiary sandstone and dune limestone.
Cape Volney to Castle Cove	Bold cliffs of Mesozoic sandstone.
Castle Cove to Point Flinders	Bold cliffs of dune limestone.
Point Flinders to north of Lorne (Eastern View)	Cliffs of Mesozoic sandstone.
Eastern View to Torquay	Cliffs of Tertiary sandstone and limestone interspersed with bays and sandy beaches.
Torquay to Cape Schanck	Sandy beach backed by dunes with intermittent low cliffs of dune limestone.
Cape Schanck to Nobbies	Bold cliffs of basalt.
South coast of Phillip Island	Sandy beaches backed by dunes with granite at Pyramid Rock and Cape Woolamai.
Cape Woolamai to Anderson's Inlet	Cliffs of Mesozoic sandstone.
Anderson's Inlet to Cape Liptrap	Sandy beach backed by dunes with low cliffs of dune limestone at south end.
Cape Liptrap Promontory	Cliffs of lower Palaeozoic sediments and diabase.
Waratah Bay as far east as Tongue Point	Sandy beach backed by dunes.
Tongue Point to Mount Hunter	Granite headlands interspersed with bays with sandy beaches backed by dunes.
Mount Hunter to Conran	Sandy beach backed by dunes with lagoons behind dunes.
Cape Conran (granite) to Cape Howe	Granite headlands with beaches between them and some local cliffs of metamorphosed lower Palaeozoic sediments at Cape Everard, Little Ram Head and near Mallacoota.

The area of Port Phillip Bay is 762 square miles and the coastline of the bay stretches for some 164 statute miles.

Rivers

Length

The characteristics of rivers which relate to land are fixed, whereas those relating to water are variable. The land or geographic features include :—

(1) The length, and

(2) the catchment.

The following table shows the main river basins of Victoria and flows of the main streams :—

VICTORIA—SCHEDULE OF FLOWS OF MAIN STREAMS

Basin No. *	Stream	Site of Gauging Station	Catchment Area (Square Miles)	Year Gauged from	Annual Flows in 1,000 Ac. Ft.			
					Mean	No. of Years	Max.	Min.
1	Murray ..	Jingellic	2,520	1890	1,974	71	4,978	549
2	Mitta	Tallandoon ..	1,840	1886	1,138	75	3,460	203
3	Kiewa	Kiewa	450	1886	527	75	1,684	146
4	Ovens	Wangaratta ..	2,100	1887	1,229	74	3,991	141
5	Broken ..	Goorambat ..	740	1887	208	74	886	15·3
6	Goulburn ..	Murchison ..	4,140	1882	2,385	79	6,139	516
7	Campaspe ..	Elmore	1,240	1886	194	75	667	0·6
8	Loddon ..	Laanecoorie ..	1,613	1891	207	70	659	8·9
9	Avoca ..	Coonooer ..	1,000	1890	62	71	321	3·8
11	Wimmera ..	Horsham ..	1,570	1889	106	72	479	0
12	Glenelg ..	Balmoral ..	606	1889 (a)	117	60	439	2·5
14	Hopkins ..	Wickliffe ..	460	1921 (b)	27	29	102	1·3
15	Carlisle ..	Carlisle	30	1930 (c)	37	26	89	14·8
17	Barwon ..	Winchelsea ..	369	1922 (d)	116	28	412	25
18	Moorarbool ..	Batesford ..	434	1908 (e)	57	16	147	2·5
19	Werribee ..	Melton	446	1917 (f)	64	43	190	5·3
20	Maribyrnong ..	Keilor	264	1908 (g)	92	30	265	3
21	Yarra	Warrandyte ..	899	1892	726	41	1,215	334
22	Bunyip ..	Bunyip	268	1908 (h)	124	47	247	55·7
24	Latrobe ..	Rosedale ..	1,604	1901 (i)	788	42	2,633	361
25	Thomson ..	Cowwarr ..	421	1891	335	68	1,050	142
25	Macalister ..	Glenmaggie ..	730	1919	478	42	1,277	181
26	Mitchell ..	Glenaladale ..	1,530	1938	814	23	1,779	368
27	Tambo ..	Bruthen	1,030	1906 (j)	179	29	575	50
28	Snowy ..	Jarrahmond ..	5,100	1907	1,682	42	3,254	766

Note	Years Excluded in Estimating Mean	Note	Years Excluded in Estimating Mean
(a)	1933–34 to 1938–39	(f)	1952–53
(b)	1933–34 „ 1943–44	(g)	1933–34 to 1955–56
(c)	1943–44 „ 1946–47	(h)	1951–52
(d)	1933–34 „ 1943–44	(i)	1919–20 „ 1936–37
(e)	1921–22 „ 1945–46	(j)	1924–25 „ 1937–38

* 10 Mallee Basin, no rivers.
23 South Gippsland Basin } Short term records only. These are not suitable for inclusion in
29 East Gippsland Basin } the table.

A table showing the lengths of streams and rivers will be found on pages 31 to 35 of the 1963 Victorian Year Book.

Catchments

Another useful characteristic of streams is their " catchment " which may be defined as the area from which there is run-off to the stream. Catchments may be regarded as the hydrologically effective part of a " basin ". Thus, the whole of any area may be subdivided into basins, but part of some basins may be regarded as non-effective, being either too flat or the rainfall too small to contribute to normal stream flows.

There is little or no contribution in the north-west of the State where the annual rainfall is less than 18 ins. to 20 ins. Above this amount, roughly half the rainfall appears as stream flow.

Figure 1 shows the 29 basins into which Victoria has been divided by the State Rivers and Water Supply Commission for hydrologic purposes.

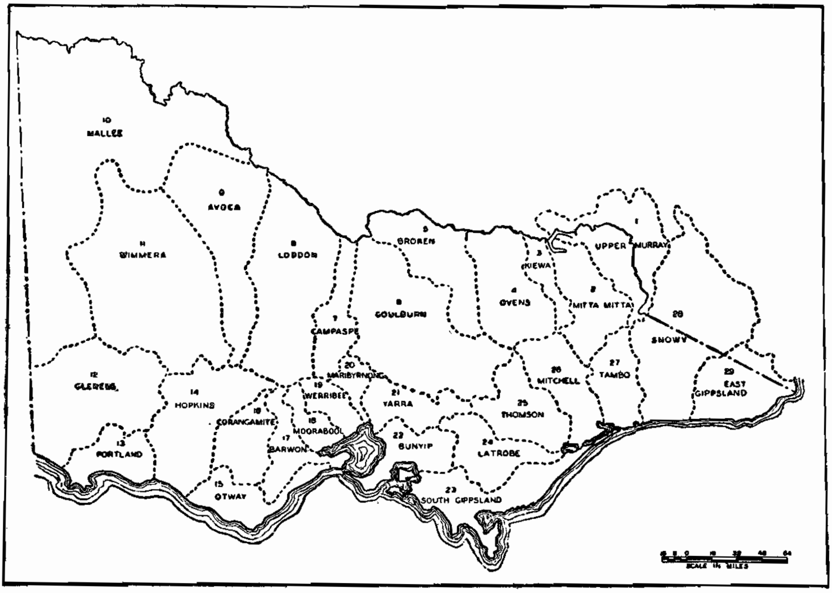


FIGURE 1.—Victoria's water resources showing key plan to river basins.

Total Flow

The current estimate of mean annual flow is 17 million acre ft. per annum, about half of which flows into the Murray; the other half flowing southward to the Victorian coast. The geographic distribution of flow is heavily weighted towards the eastern half where the total flow is about 14 million acre ft. (with about 8 million acre ft. in the north-east and 6 million acre ft. in the south-east) and hence leaving 3 million acre ft. in the western half.

Location of Streams

The location of about 2,500 streams in Victoria may be obtained by referring to the " Alphabetical Index of Victorian Streams " compiled by the State Rivers and Water Supply Commission in 1960. Owing to the replication of names for some streams there are over 2,900 names; these have been obtained by examining Department of Lands and Survey, and Commonwealth Military Forces maps, so as to include names which have appeared on them. There are, in addition, many unnamed streams, those with locally known names, and those named on other maps or plans. No attempt was made in the Index to suggest a preferred name, as it was considered that further legislation is necessary before any such action can be made effective.

Stream Reserves

In 1881, under the then current Land Act, an Order in Council created permanent reserves along the banks of streams where they passed through Crown Land. These are scheduled in the " Township and Parish Guide " reprinted by the Lands Department in 1955. This schedule indicates the location and width of reservations for 280 streams which (except for the Murray) are 1, 1½, or 2 chains wide on *each* bank of the stream. The areas thus reserved were not fully delineated until subsequently surveyed prior to alienation.

Stream Flows

Under the Water Act, the State Rivers and Water Supply Commission was given the duty of systematically gauging, recording, and publishing the flow of rivers within the State, a function which had been undertaken by its predecessor, the Victorian Water Supply Department.

The State Rivers and Water Supply Commission has published, usually at intervals of six years, eight volumes of " River Gaugings " which show the minimum, maximum, and mean flows for each month of record. In the earliest and latest volumes, data concerning measurements or gaugings is also provided to assist in assessing the reliability of the published figures. Such records form the basis of hydrologic studies, such as estimation of regulated output from storages, optimum channel, and spillway capacity.

Floods

Since rainfall intensity increases with the decrease in latitude, Victoria is less subject to floods than the northern States. Protection has been provided against floods in occupied areas by levees, which have been constructed along parts of the Murray, Snowy, and Goulburn rivers, and Dandenong creek. Levees, however, restrict the flood plain, and, hence, increase the flood level for a given discharge. If overtopping occurs, the damage is more serious. Other preventive measures involve straightening the streams, thus increasing the gradient and flow rate.

So-called " creeping floods " may occur where the levels of lakes rise because a series of wet years upsets the balance between evaporation and inflow. In the Lake Corangamite region, rainfall was almost 25 per cent. above average for the six years 1951 to 1956, causing an 11 feet rise in the level of the lake, which increased its area by 20 per cent., and inundated some 20 square miles of marginal lands. To assist in the lowering of the lake level by natural evaporation, provision has been made for diverting the flow of the main stream feeding the lake.

It is often difficult to determine the relative magnitude of major floods. The difficulty is magnified by the necessity for maintaining records of the level of the gauge in relation to a permanent datum, if a true comparison is to be made. Although the year 1870 is regarded as the wettest that Victoria has experienced for over a century, the estimate of the average of 38 inches over the State is crude, as there were only thirteen rainfall stations whose records are available, and estimates of flood flows for this year are necessarily poor. Owing in part to an under-estimation of earlier floods, the protection at the State Electricity Commission works at Yallourn was inadequate and the 1934 flood overflowed the banks of the Latrobe into the Open Cut.

Droughts

The expenditure incurred in Victoria on flood mitigation is negligible by comparison with that on storages required to meet water needs in droughts. Although there is no universal definition of drought, it is obvious that any definition must involve a duration of time. The definition need not be limited to rainfall, as a measure of drought could be applied to streams which cease to flow. In the case of perennial streams, volumes of flow over a specified duration would be needed. Analyses of Victorian streams having up to 70 years of records, show that the mean flow over the *worst* ten years may be less than half the long term mean flow.

Droughts are more widespread than floods, but, owing to climatic differences between the eastern and western parts of Victoria, there will be differences in regard to the severity of a drought in different regions. It is essential to provide water supplies during drought periods, and it has proved necessary to store more than the winter flows for use in the following summer, as such winter flows may fail. The summer output would then be curtailed unless flows from previous years have been retained in storage. It is wishful thinking, however, to presume that all waste can be eliminated, as there is an economic limit to storage capacity. It is reasonable to assume that the magnitude of past droughts will be exceeded in the future ; thus, it is not possible to guarantee a particular output from storages, and for irrigation purposes at least, restrictions could well be imposed in years of severe drought.

Lakes

For lakes to form, there must be suitable physiographic features and sufficient water supply to offset evaporation and seepage losses. Although the water supply in the western part of the State is comparatively poor, the majority of Victorian lakes occur in the west because of suitable physiography which is attributable to volcanic activity. Some extinct volcanoes carry crater lakes, and on the volcanic plains numerous lakes have been formed, the largest being Lake Corangamite. Lakes on the plains are relatively shallow, their depth and hence volume varying considerably with climatic trends in rainfall.

Lakes also occur in the north-west plains, some of which are intermittently replenished by effluents from rivers. Another type of lake is that which occurs along the coast by sand bars forming across the mouth of a stream. The Gippsland Lakes constitute the main lake system of this type.

C.4300/63.—**2**

Although lakes are often described as "salt" or "fresh", such a classification is misleading in shallow lakes as salinity varies inversely with the volume of water in the lake. Certain Victorian lakes are so shallow that salt is deposited in the summer when evaporation is high and in some cases, such as Lake Tyrell, it is harvested.

State Aerial Survey

Information about the State Aerial Survey and a list of available printed maps will be found on pages 35–36 of the Victorian Year Book 1961.

Physical Geography

Physical Divisions

This article should be read in conjunction with the articles on geographical features, area, and climate.

The chief physical divisions of Victoria are shown on the map (Fig. 2). Each of these divisions has certain physical features which distinguish it from the others, as a result of the influence of elevation, geological structure, climate, and soils, as is recognized in popular terms such as Mallee, Wimmera, Western District and so on. The following is a table of these divisions :—

1. *Murray Basin Plains :*
   - (*a*) The Mallee
   - (*b*) The Murray Valley
   - (*c*) The Wimmera
   - (*d*) The Northern District Plains

2. *Central Highlands :*
   - A. The Eastern Highlands, within which—
     - (*a*) the Sandstone Belt and
     - (*b*) the Caves Country may be distinguished from the remainder
   - B. The Western Highlands :
     - (*a*) The Midlands
     - (*b*) The Grampians
     - (*c*) The Dundas Highlands

3. *Western District Plains :*
   - (*a*) The Volcanic Plains
   - (*b*) The Coastal Plains

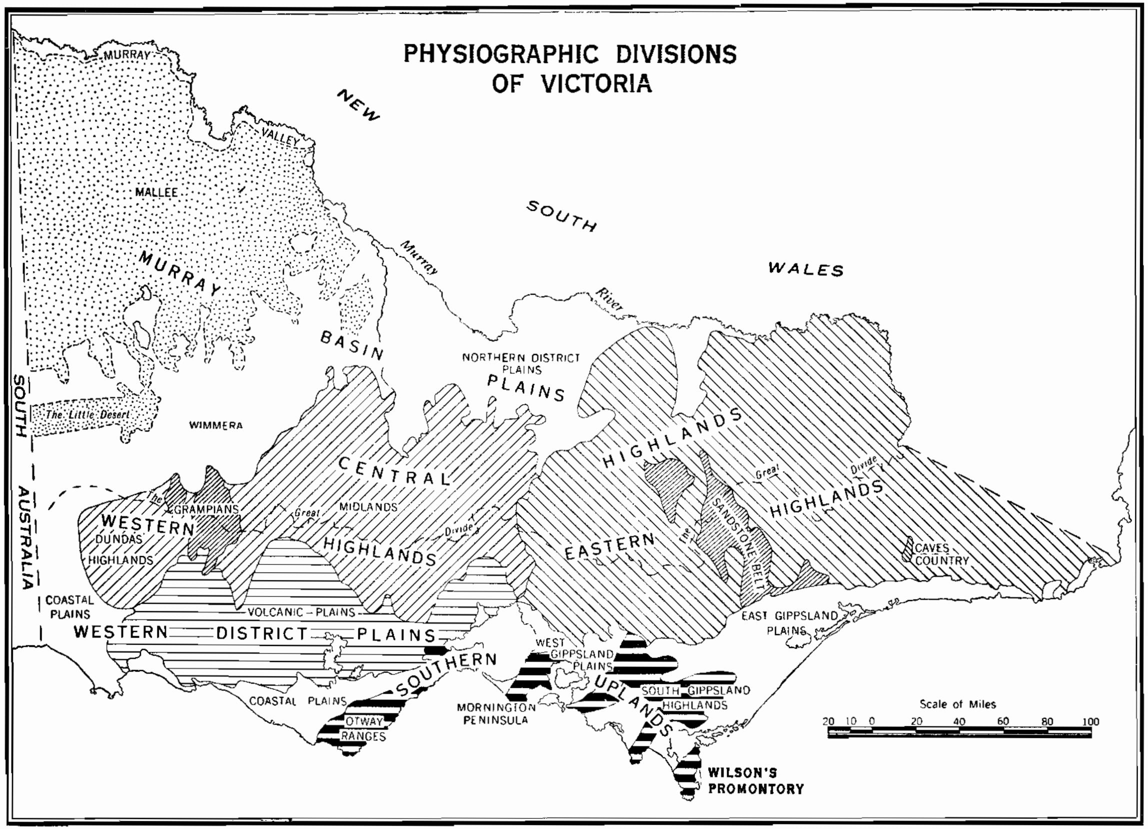

PHYSIOGRAPHIC DIVISIONS
OF VICTORIA
NEW
SOUTH
WALES
MURRAY
VALLEY
MALLEE
MURRAY
BASIN
Murray
River
NORTHERN DISTRICT
PLAINS
PLAINS
The Little Desert
WIMMERA
SOUTH
AUSTRALIA
CENTRAL
HIGHLANDS
The GRAMPIANS
Great
MIDLANDS
Divide
HIGHLANDS
WESTERN
DUNDAS
HIGHLANDS
COASTAL
PLAINS
VOLCANIC – PLAINS
WESTERN DISTRICT PLAINS
EASTERN
HIGHLANDS
Great
Divide
HIGHLANDS
The
SANDSTONE BELT
CAVES
COUNTRY
EAST GIPPSLAND
PLAINS
WEST
GIPPSLAND
PLAINS
SOUTHERN
UPLANDS
SOUTH GIPPSLAND
HIGHLANDS
COASTAL PLAINS
OTWAY
RANGES
MORNINGTON
PENINSULA
WILSON'S
PROMONTORY
Scale of Miles
20 10 0 20 40 60 80 100

FIGURE 2.

4. *Gippsland Plains:*
   - (*a*) The East Gippsland Plains
   - (*b*) The West Gippsland Plains

5. *Southern Uplands:*
   - (*a*) The Otway Ranges
   - (*b*) The Barabool Hills
   - (*c*) The Mornington Peninsula
   - (*d*) The South Gippsland Highlands
   - (*e*) Wilson's Promontory

Murray Basin Plains

These plains include the Mallee, the Wimmera, the Northern District Plains and the Murray Valley itself. The most noticeable distinguishing features of the Mallee are the soils, vegetation, and topography. It is not a perfect plain, but exhibits broad low ridges and depressions which appear to be due to folding and faulting of the rocks. Sand ridges trending due east and west are an indication of a former more arid climate, but they are now fixed by vegetation. When cleared, the sand distributes itself irregularly without forming new ridges. There is evidence of a succession of former wet and dry periods in the Mallee, but at the present time all the streams that enter it lose so much water by evaporation and percolation that they fail to reach the Murray and terminate in shallow lakes, many of which are salt. The Murray Valley itself is cut into the higher Mallee land and is subject to periodical flooding by the river.

The Northern District Plains are formed from the combined flood plains of rivers flowing to the Murray, with an average gradient of between 3 and 5 feet to the mile, the surface being almost perfectly flat except where small residual hills of granite rise above the alluvium as at Pyramid Hill.

The Wimmera lies between the Western Highlands and the Mallee and is also composed mainly of river plains except to the north of the Glenelg where old abandoned river channels contain a succession of small lakes. Most of the lakes of the Murray Basin Plains have crescentic loam ridges (lunettes) on their eastern shores.

Central Highlands

The Central Highlands form the backbone of Victoria, tapering from a broad and high mountainous belt in the east until they disappear beyond the Dundas Highlands near the South Australian border. They were formed by up-warping and faulting. The Eastern Highlands differ from the Western in their greater average elevation, with peaks such as Bogong, Feathertop, and Hotham rising above 6,000 feet, while the Western Highlands are generally lower, the peaks reaching above

3,000 feet, and the valleys being broader. Also, in the Eastern Highlands patches of Older Volcanic rocks occur, whereas in the Western the volcanic rocks belong mainly to the Newer Volcanic Series. Several well known volcanic mountains are still preserved, Mounts Buninyong and Warrenheip near Ballarat being examples.

Because of the great variety of geological formations in the Central Highlands and the effects of elevation and deep dissection by streams, the features of the country are very varied and there are many striking mountains and gorges. The severe winter climate, with heavy snow on the higher land, is also a special feature of the Eastern Highlands. Included in the area are several high plains such as those near Bogong and the Snowy Plains. Caves are well known in the limestone around Buchan.

In the Western Highlands the Grampians, with their striking serrate ridges of sandstone, may be compared with the belt of sandstones stretching from Mansfield to Briagolong in the east.

The Dundas Highlands are a dome which has been dissected by the Glenelg and its tributaries, the rocks being capped by ancient laterite soils which form tablelands with scarps at their edges.

Western District Plains

Many of the surface features of the Western District Plains are a result of volcanic activity, very large areas being covered with basalt flows of the Newer Volcanic Series above which prominent mountains rise, many of them with a central crater lake. Some of the youngest flows preserve original surface irregularities practically unmodified by erosion, thus forming the regions known as " Stony Rises ".

The coastal plains of the Western District are for the most part sandy, the soils being derived from Tertiary and Pleistocene sedimentary deposits, which in places attain a thickness of some 5,000 feet, and yield considerable quantities of artesian water.

Gippsland Plains

Continuing the east-west belt of plains on the eastern side of the drowned area represented by Port Phillip Bay and Western Port Bay are the Gippsland Plains. These are underlain by marine and non-marine Tertiary and Pleistocene sedimentary deposits, including the thick seams of brown coal of the Latrobe Valley. A notable feature is the Ninety Mile Beach and the lakes and swamps that lie on its landward side. This beach is an off-shore bar on which aeolian sand ridges have accumulated.

Southern Uplands

Lying to the south of the plains above mentioned is a group of uplifted blocks for which faulting is mainly responsible, these constituting the Southern Uplands. The Otway Ranges and the South

Gippsland Highlands are composed of fresh-water Mesozoic and Tertiary sediments with Older Volcanic basalts in South Gippsland, and the Mornington Peninsula is an upraised fault block of complex geology, including granites. The Sorrento Peninsula is entirely composed of Pleistocene calcareous dune ridges which have been responsible for practically blocking the entrance to Port Phillip Bay.

Land Surface of Victoria

The surface features of Victoria were brought into existence as a result of the sum total of all geological events that have affected the region over many millions of years in the past. The understanding of the physical features of the State cannot, therefore, be divorced from a study of its geological history. This applies not only to the various rock masses of granite, basalt, schist, sandstone, limestone, and so on, which are to be found in the different regions of the State and which have characteristic topography, soils and vegetation, but also to remnants of ancient erosional or depositional surfaces that are preserved in many of the landscapes.

Mesozoic Peneplain

Many of the regions of hard rocks such as granite and Devonian dacite in Victoria have plateau summits which are relics of an ancient peneplain, once thought to be Cretaceous, but now recognized as older and perhaps Jurassic in age. During the Jurassic period this old land surface was deformed by down-warps in which non-marine beds were deposited and by up-warps which began to outline the Central Highlands of the State. The presence of marine Cretaceous rocks discovered in bores in western Victoria indicates that an ancient Bass Strait was already in existence at this time. In the Central Highlands, which were not then as high as they are today, streams cut broad valleys in which gold-bearing gravels were deposited in places during the early Tertiary period, and in the lower lands thick deposits of brown coal, clay and sand were laid down. The Older Volcanic basalt flows were extruded during Eocene and Oligocene times and renewed earth movements led to the sea invading southern and western Victoria and the Mallee. At its maximum advance the sea reached nearly as far as Broken Hill in New South Wales in a large embayment known as the Murray Gulf, but after the Miocene period it retreated and Victoria gradually assumed its present configuration. The uplift that accompanied the retreat of the sea caused deep erosion in the highlands and deposition of sands, gravels and clays in the low-lying plains. The Newer Volcanic lava flows and tuffs were extruded after the sea had retreated from western Victoria and it is worth noting that in Port Phillip Bay we have an area which is still a marine transgression over the land. The submergence of Port Phillip and Western Port Bays was partly due to down-faulting and partly to the rise of sea level that occurred all over the world when the ice masses of the great ice age (Pleistocene) melted. This rise of sea level also cut off Tasmania from the mainland.

The various movements which have affected Victoria have not completely ceased, as is shown by the occurrence of earthquakes, some of which have been of moderate severity.

Not only has the State been affected by these various changes of elevation and advances and retreats of sea level, but the climate has changed also. In the later and middle Tertiary period it appears to have been much wetter and warmer, becoming drier in the Pliocene and wetter again during parts of the Pleistocene period. Even in geologically recent times there has been at least one period of aridity during which the sand ridges of the Mallee and of the sand belt between Brighton and Mordialloc were blown up.

The final influence on the surface of Victoria has been man himself by the clearing of forests, irrigation, drainage, the sowing of pastures and orchards, the cutting of roads and the building of dams. Accelerated soil erosion has been one of the serious effects of man's activity, but fortunately we are able to control this by various means, although continual effort is required. Similar effects of man's activities are to be seen along the coast where the building of breakwaters and groins, while often beneficial in some places, has also had adverse effects in causing unwanted erosion or the deposition of sand.

Further References

Geology of Victoria—Victorian Year Book 1961, pages 42 to 56.

E. S. Hills *The Physiography of Victoria* : Whitcombe and Tombs, Melbourne, Fourth Edition, 1959.

Resources Surveys—Preliminary Reports : Published by the Central Planning Authority, Premier's Department, Melbourne.

Climate

Climate of Victoria

General

The State of Victoria experiences a wide range of climatic conditions ranging from the hot summer of the Mallee to the winter blizzards of the snow-covered Alps, and from the relatively dry wheat belt to the wet eastern elevated areas where many of Victoria's permanent streams spring.

Temperatures

February is the hottest month of the year with January only slightly cooler. Average maximum temperatures are under 75° F. along the coast and over elevated areas forming the Central Divide and North-East Highlands. Apart from these latter areas, there is a steady increase towards the north, until, in the extreme north an average of 90° F. is reached. Values decrease steadily with height, being under 70° F. in alpine areas above 3,000 feet and as low as 60° F. in the very highest localities.

Temperatures fall rapidly during the autumn months and then more slowly with the onset of winter. Average maximum temperatures are lowest in July ; the distribution during this month again shows lowest values over elevated areas, but a significant feature is that apart from this orographically induced area, there is practically no variation across the State. Day temperatures along the coast average about 55° F. in July; much the same value is recorded over the wheat belt, and only a few degrees higher in the far north-west under conditions of few clouds and relatively high winter sunshine. The Alps experience blizzard conditions every year with minimum temperatures 10° F. to 20° F. less than at lowland stations.

Conditions of extreme summer heat may be experienced throughout the State except over the alpine area. Most inland places have recorded maxima over 110° F. with an all time extreme for the State of 123.5° F. at Mildura on 6th January, 1906. Usually such days are the culmination of a period during which temperatures gradually rise, and relief comes sharply in the form of a cool change with rapid temperature drops of 30° F. at times. However, such relief does not always arrive so soon and periods of two or three days or even longer have been experienced when the maximum temperature exceeds 100° F. On rare occasions extreme heat may continue for as long as a week with little relief.

Night temperatures, as gauged by the average minimum temperature, are, like the maximum, highest in February. Values are below 50° F. over the elevated areas, but otherwise the range is chiefly 55° F. to 60° F. The highest night temperatures are recorded in the far north and along the coast. In mid-winter, average July minima exceed 40° F. along the coast and at two or three places in the far north. The coldest point of the State is the north-east alpine section, where temperatures frequently fall below freezing point. Although three or four stations have been set up at different times in this area, none has a very long or satisfactory record. The lowest temperature on record so far is 9° F. at Hotham Heights (Station height 5,776 feet) at an exposed location near a mountain. However, a minimum of minus 8° F. has been recorded at Charlotte Pass (Station height 6,035 feet)—a high valley near Mount Kosciusko in N.S.W.—and it is reasonable to expect that similar locations in Victoria would experience sub-zero temperatures (i.e., below 0° F.), although none has been recorded due to lack of observing stations.

Frosts

With the exception of the exposed coast, all parts of Victoria may experience frost, but frequencies are highest and occurrences usually more severe in elevated areas and valleys conducive to the pooling of cold air. All inland stations have recorded extreme screen temperatures less than 30° F., whilst at a large number of stations extremes stand at 25° F. or less. Thus frost may be expected each year over practically the whole of the State, but the bulk of the occurrence is restricted to the winter season. Spring frosts may constitute a serious hazard to agriculture, and in some years a late frost may result in serious crop damage. Periods of frost over Victoria longer than three or four days are most unusual.

Rainfall

Rainfall exhibits a wide variation across the State and although not markedly seasonal, most parts receive a slight maximum in the winter or spring months. The relatively dry summer season is a period of evaporation, which greatly reduces the effectiveness of the rainfall. Average annual totals range between 10 inches in the driest parts of the Mallee to over 60 inches in parts of the North-Eastern Highlands. An annual total exceeding 140 inches has been reported from Falls Creek in the north-east; however, with the sparse population and inaccessibility of the highland localities, it is not practicable to obtain a representative set of observations from this area. Most areas south of the Divide receive an annual rainfall above 25 inches, with over 40 inches in the Central Highlands, Otway Ranges and South Gippsland. The wheat belt receives chiefly between 12 and 20 inches. With the exception of Gippsland, 60 to 65 per cent. of the rain falls during the period May to October. This proportion decreases towards the east, until over Gippsland the distribution is fairly uniform with a warm season maximum in the far east. All parts of the State have on rare occasions been subjected to intense falls, and monthly totals exceeding three times the average have been recorded. Monthly totals exceeding 10 inches have been recorded on rare occasions at most places on and south of the Divide; the chief exception being over the lowlands extending from Melbourne to the Central Western District. Occurrences are more frequent, but still unusual, over the north-east and East Gippsland and isolated parts such as the Otways. This event has, with few exceptions, never been recorded over the north-west of the State. The highest monthly total ever recorded in the State was a fall of 35·09 inches at Tanybryn in June, 1952.

Floods

Floods have occurred in all districts, but they are more frequent in the wetter parts of the State such as the north-east and Gippsland. However, although a rarer event over the North-West Lowlands, they may result from less intense rainfall and continue longer owing to the poor drainage in this section of the State. In many instances the frequency of flooding is increased by valley contours and damage is often greater because of the higher density of adjacent property and crops. (See also page 18.)

Snow

Snow in Victoria is confined usually to the Great Dividing Range and the alpine massif, which at intervals during the winter and early spring months may be covered to a considerable extent, especially over the more elevated eastern section. Falls elsewhere are usually light and infrequent. Snow has been recorded in all districts except the Mallee, Wimmera, and Northern Country. The heaviest falls in Victoria are confined to sparsely populated areas and hence general community disorganization is kept to a minimum. Snow has been recorded in all months on the higher Alps, but the main falls occur during the winter. The average duration of the snow season in the alpine area is from three to five months.

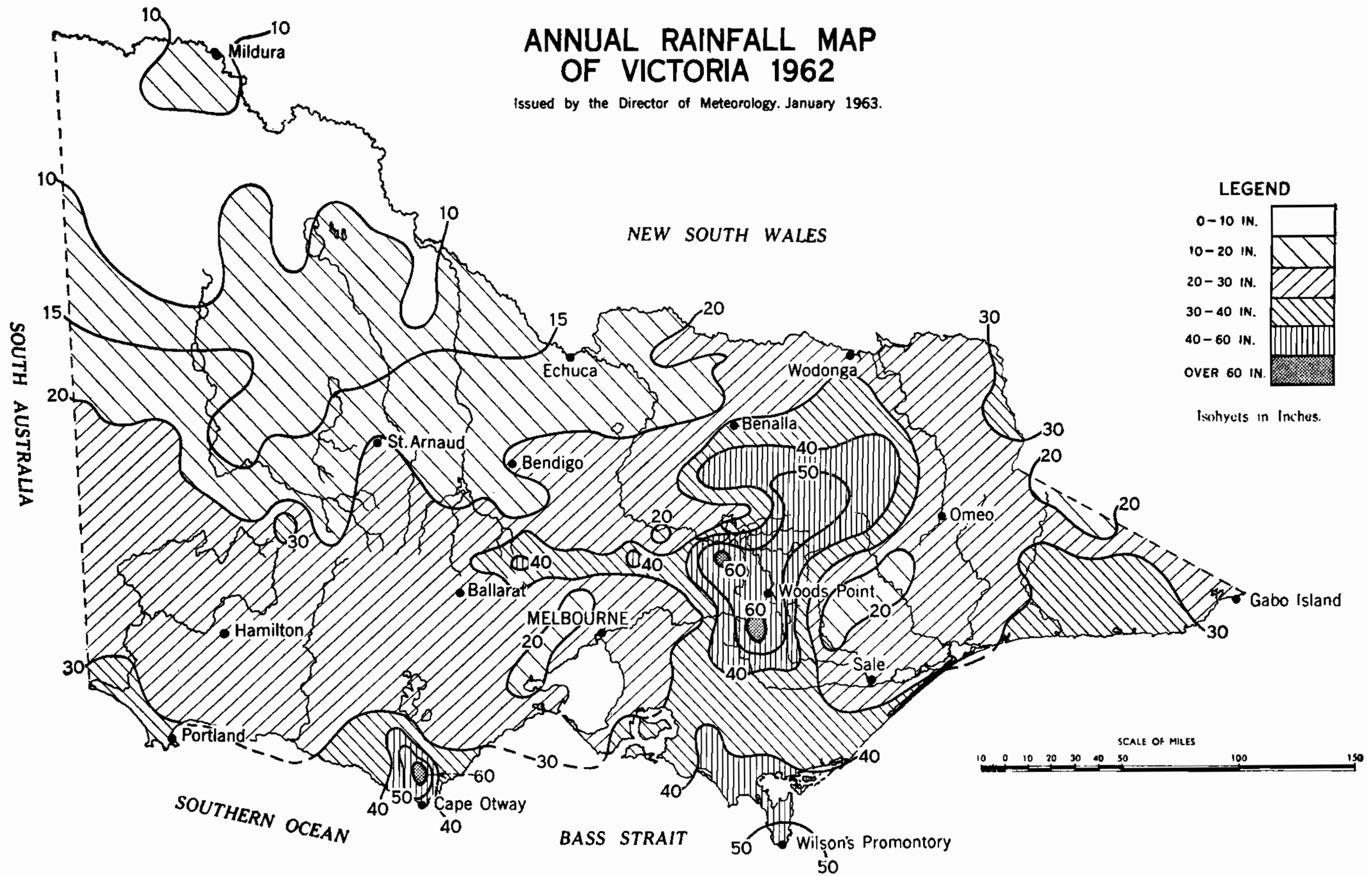

ANNUAL RAINFALL MAP
OF VICTORIA 1962
Issued by the Director of Meteorology. January 1963.
LEGEND
0–10 IN.
10–20 IN.
20–30 IN.
30–40 IN.
40–60 IN.
OVER 60 IN.
Isohyets in Inches.
SCALE OF MILES
10 0 10 20 30 40 50 100 150
NEW SOUTH WALES
SOUTH AUSTRALIA
SOUTHERN OCEAN
BASS STRAIT
Mildura
Echuca
Wodonga
Benalla
St. Arnaud
Bendigo
Omeo
Ballarat
Woods Point
Hamilton
MELBOURNE
Sale
Gabo Island
Portland
Cape Otway
Wilson's Promontory
10
15
20
30
40
50
60

FIGURE 3.

Winds

The predominant wind stream over Victoria is of a general westerly origin, although it may arrive over the State from the north-west or south-west. There are wide variations from this general description, however, and many northerlies and southerlies are experienced. The latter is the prevailing direction from November to February with a moderate percentage of northerlies often associated with high temperatures. Easterly winds are least frequent over Victoria, but under special conditions can be associated with some of the worst weather experienced over the State. Wind varies from day to night, from season to season, and from place to place. Examples of the diurnal variation are the sea breeze, which brings relief on many hot days along the coastline, and the valley or katabatic breeze, which brings cold air down valleys during the night. The latter is well developed in many hilly areas of Victoria, being the result of differential cooling after sunset. It springs up during the night, often suddenly, and continues after sunrise until the land surfaces are sufficiently heated again. The sensitive equipment required to measure extreme wind gusts has been installed at only about five or six places in the State and to date the highest value recorded is just slightly over 90 m.p.h. There is no doubt, however, that stronger gusts have been experienced over the State, although not in the vicinity of a recording anemometer. A number of tornadic squalls have been experienced and from the severe local damage engineers have estimated wind strengths over 100 m.p.h. It is considered that any place in Victoria could feasibly experience at some time a local gust of 100 m.p.h. or more.

Droughts

There have been numerous dry spells over the State, most of them of little consequence, but many long enough to be classified as a drought. The latter was recognized as an agricultural hazard in Victoria from the middle of the previous century when population was extending into drier areas of the State. There have been less than ten significant drought periods during the last fifty years. The State of Victoria is situated on the northern fringe of the belt of prevailing westerly winds, which results in fairly uniform and reliable rainfall throughout the year. By and large, Victoria has a rather equable climate. Although severe droughts, devastating floods, scorching bush fires and severe storms are experienced from time to time, compared with other places in Australia and elsewhere over the world, the climate of Victoria is well behaved. (See also page 19.)

Thunderstorms

Thunderstorms occur far less frequently in Victoria and Tasmania than in the other two eastern States. They occur mainly in the summer months when there is adequate convective heat to provide energy. On an average, more than 20 per year occur on the North-Eastern Highlands and in parts of the Northern Country, but particularly in the north-east. Melbourne has an average of less than three in November, and in each of the summer months. Isolated severe wind squalls and tornadoes sometimes occur in conjunction with thunderstorm conditions, but these destructive phenomena are comparatively rare. Hailstorms affect small areas in the summer months ; and showers of small hail are not uncommon during cold outbreaks in the winter and spring.

Humidity

By and large, humidity in the lower atmosphere is much less over Victoria than in other eastern States. This is because the extreme south-east of the continent is mostly beyond the reach of tropical and sub-tropical air masses. For several periods in the summer, however, air from the Tasman Sea has a trajectory over Bass Strait and other parts of the State, and it is then that the moisture content rises to show wet bulb temperatures above 60° F. The incidence of high humidity is important to the vine and fruit industry, tobacco growers, and wheat farmers.

Evaporation

Measurements of evaporation in Victoria are made with the standard form of evaporation tank at about 27 stations, about half of which are owned by the Commonwealth Bureau of Meteorology. Results from these stations show that evaporation exceeds the average annual rainfall in inland areas, especially in the north and north-west, by about 40 inches. In all the Highland areas and the Western District the discrepancy is much less marked, and in the Central District and the lowlands of East Gippsland annual evaporation exceeds annual rainfall by 8 to 15 inches. Evaporation is greatest in the summer months in all districts. In the three winter months, rainfall exceeds evaporation in many parts of Victoria, but not in the north and north-west.

As a consequence of the awakening of various authorities to the vital importance of evaporation in agricultural and hydrological studies, the Australian network of recording stations has almost doubled during the past twenty years.

Rainfall Reliability

It is not possible to give a complete description of rainfall at a place or in a district by using a single parameter. The common practice of quoting the annual average rainfall alone is quite inadequate in that it does not convey any idea of the extent of the variability likely to be encountered. Examination of rainfall figures over a period of years for any particular place indicates a wide variation from the average ; in fact it is rare for any station to record the average rainfall in any particular year. Thus for a more complete picture of annual rainfall the variability or deviation from the average should be considered in conjunction with the average.

Rainfall variability assumes major importance in some agricultural areas. Even though the average rainfall may suggest a reasonable margin of safety for the growing of certain crops, this figure may be based on a few years of heavy rainfall combined with a larger number of years having rainfall below minimum requirements. Variability of rainfall is also important for water storage design, as a large number of relatively dry years would not be completely compensated by a few exceptionally wet years when surplus water could not be stored.

Although variability would give some indication of expected departures from normal over a number of years, variability cannot be presented as simply as average rainfall.

Several expressions may be used to measure variability, each of which may have a different magnitude. The simplest form of variability is the range, i.e., the difference between the highest and lowest annual amounts recorded in a series of years. Annual rainfall in Victoria is assumed to have a " normal " distribution. These distributions can be described fully by the mean and standard deviation. To compare one distribution with the other, the co-efficient of variation $\left(\frac{\text{standard deviation}}{\text{the average}}\right)$ has been used. The coefficient of variation has been calculated for the fifteen climatic regions of Victoria (see Fig. 4) for the 30 years 1913 to 1942 and the results are tabulated below in order of rainfall reliability :—

VICTORIA—RAINFALL VARIATION

District	Average Rainfall	Standard Deviation	Coefficient of Variation
	points*		
1. West Coast	2960	347	0·117
2. West Gippsland	3468	519	0·150
3. Volcanic Plains	2390	388	0·162
4. East Gippsland	2940	485	0·165
5. East Central	3530	589	0·167
6. Wimmera South	1911	355	0·186
7. West Central	2350	446	0·190
8. Wimmera North	1583	321	0·203
9. North Central	2666	615	0·231
10. Mallee South	1326	334	0·252
11. Upper North-east	4299	1113	0·259
12. Lower North-east	2985	825	0·276
13. Upper North	1964	546	0·278
14. Lower North	1658	468	0·282
15. Mallee North	1155	344	0·298

*100 points=One inch.

The higher the value of the coefficient of variation of the rainfall of a district, the greater the departure from the average and hence the more unreliable the rainfall.

Most of the elevated areas of eastern and southern Victoria normally receive over 40 inches and over 60 inches in some wetter sections. Interspersed between these wet mountainous areas are sheltered valleys which are deprived to some extent of their rainfall

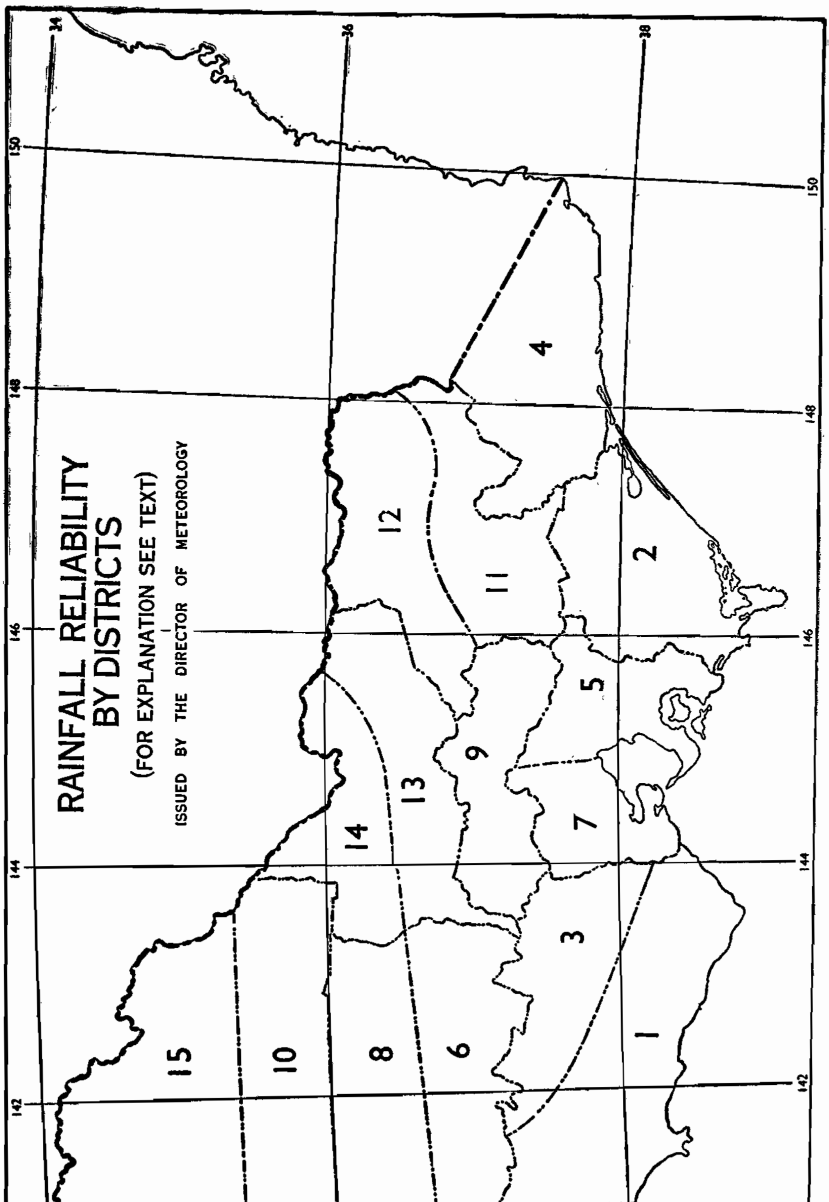


FIGURE 4.—Relative rainfall variability based on district annual rainfall. Names of districts are shown in table on page 31.

by neighbouring highlands. Along practically the whole south coastline of Victoria the average number of wet days (0·01 inches or more in 24 hours) is over 150, with an average rainfall below 30 inches. The average number of wet days a year is reduced to 100 at a distance of approximately 100 miles inland from the coast.

The variability of annual rainfall is closely associated with the incidence of drought. Droughts are rare over areas of low rainfall variability and more common in areas where this index is high.

Agricultural Meteorology

Introduction

In a country like Australia, with a dry interior and a southern coastal fringe of comparatively low rainfall supporting most of the population, it is essential that the greatest possible use be made of knowledge about the climate, in order to increase productivity and to minimize losses from bad seasons and from disastrous floods and bushfires.

The yield of food depends on the seed, the soil, the climate, and the knowledge of man. Agricultural meteorology is concerned with the effects of weather and climate on food production, and some knowledge about this must be passed on to the farmer and the agricultural scientist. Climate is the greatest single factor in determining the type of vegetation that will grow in any part of the world. The agricultural meteorologist continually strives to forge new links between climate and agriculture. A climatic survey of an area can supply information which can help to establish the best crop suited to that area. In Victoria, climatic surveys have been prepared for most of the regions into which the State has been divided for regional planning purposes. (See Victorian Year Book 1962, pages 421 to 423.)

Failure to plant the best crop in an area can result in soil erosion. As climate and the weather have a strong bearing on this, the meteorologist must help in checking soil erosion.

Rainfall is one of the most variable of meteorological elements, and irrigation, used to counterbalance the irregularity of rainfall and evapo-transpiration, is almost the only existing method of climatic " control ". Evapo-transpiration is dependent on temperature, humidity, sunshine, and wind. These can be measured and a possible figure estimated for the loss of moisture from the soil. As the incoming moisture, i.e., rainfall, is also measured, a system of controlled irrigation can be established to maintain an optimum moisture in the soil.

The provision of shelter belts, the determination of adequate storage conditions for food, and frost prevention, are other forms of control in which meteorology can provide advice.

Certain types of weather give rise to pests and diseases. This is another field in which agricultural meteorology can make significant contributions. Thus, daily forecasts are prepared during the summer to determine whether or not spraying operations should be carried out against sporulation of blue mould on tobacco crops in the Ovens Valley.

Specific Services

The Commonwealth Bureau of Meteorology calculates expected bush and grass fire danger ratings and issues advice on this in the form of forecasts and warnings available to the man on the land. Forecasts are also provided for such aviation agricultural activities as fertilizing and crop dusting.

In Victoria, as in other States of Australia, services available to the man on the land include :—

(1) *District forecasts*. These are disseminated by radio, television, and the press. Especially intended for the primary producer, they cover approximately 24 to 36 hours from the time of issue, but on occasions may be extended to 48 hours or more by the addition of a " further outlook " which depends on the certainty with which conditions can be predicted for the longer period.

(2) *Extended forecasts*. On Monday and Thursday afternoons the Bureau issues forecasts up to 3 or 4 days ahead. These include likely developments significant to agricultural activities such as harvesting.

(3) *Warnings*. These include warnings of cold snaps during the lambing and shearing seasons, frost warnings, flood and fire warnings.

Use of the weather service goes further than obtaining and applying the forecasts and warnings. A knowledge of how much rain has fallen, the lowest and highest daily temperatures, the speed of the wind, and the general picture of the controlling features of the weather are all of value and interest to the farmer.

The daily 9 a.m. weather observations are published each morning in the form of bulletins, rain lists, rain maps, river height reports, and synoptic weather charts. These are issued to the press and to the national broadcasting service, and are displayed at the General Post Office in Melbourne. These daily publications are available to subscribers. Weekly and monthly climatological and other publications are also available.

Climate of Melbourne

Temperatures

The proximity of Port Phillip Bay bears a direct influence on the local climate of the Metropolis. The hottest months in Melbourne are normally January and February when the average is just over 78° F. Inland, Watsonia has an average of 81° F., whilst along the Bay, Black Rock, subject to any sea breeze, has an average of 77° F. This difference does not persist throughout the year, however, and in July average maxima at most stations are within 1° F. of one another at approximately 55° F. The hottest day on record in Melbourne was January 13, 1939, when the temperature reached 114.1° F. which is the second highest temperature ever recorded in an Australian Capital City. In Melbourne, the average number of days per year with maxima over 100° F. is about four, but there have been years with up to twelve and also a few years with no occurrences. The average annual number of days over 90° F. is just on nineteen.

Nights are coldest at places a considerable distance from the sea such as at Watsonia, which has a good open exposure and where average minima are a few degrees lower than those observed in the City, for there buildings may maintain the air at a slightly higher temperature. The lowest temperature ever recorded in the City was 27° F. on 21st July, 1869, and likewise, the highest minimum ever recorded was 87.0° F. on February 1, 1902.

In Melbourne, the average overnight temperature remains above 70° F. on only about two nights a year and this frequency is the same for nights on which the air temperature falls below 32° F. Minima below 30° F. have been experienced during the months May to August, whilst even as late as October, extremes have been down to 32° F. During the summer, minima have never been below 40° F.

Wide variations in the frequencies of occurrences of low air temperatures are noted across the Metropolitan Area. For example, there are approximately ten annual occurrences of 36° F. or under around the bayside, but frequencies increase to over twenty in outer suburbs and probably to over 30 a year in the more frost susceptible areas. The average frost free period is about 200 days in the outer northern and eastern suburbs, gradually increasing to over 250 days towards the City, and approaches 300 days along parts of the bayside.

Rainfall

The range of rainfall from month to month in the City is quite small, the annual average being 25·91 inches over 143 days. From January to August, monthly averages are within a few points of two inches ; then a rise occurs to a maximum of 2·71 inches in October. Rainfall is relatively steady during the winter months when the extreme range is from half an inch to five inches, but variability increases towards the warmer months. In the latter period totals range between practically zero and over seven and a half inches. The number of wet days, defined as days on which a point or more of rain falls, exhibits marked seasonal variation ranging between a minimum of eight in January and a maximum of fifteen each in July and August. This is in spite of approximately the same total rainfall during each month and indicates the higher intensity of the summer rains. The relatively high number of wet days in winter gives a superficial impression of a wet winter in Melbourne which is not borne out by an examination of total rainfall.

The highest number of wet days ever recorded in any one month is 27 in August. On the other hand, there has been only one rainless month in the history of the Melbourne records—April, 1923. On occasions, each month from January to May, has recorded three wet days or less. The longest wet spell ever recorded was sixteen days and the longest dry spell 40 days. Over four inches of rain have been recorded in 24 hours on several occasions, but these have been restricted to the warmer months, September to March. No fall above 2 inches in 24 hours has ever been recorded in the cooler months.

Fogs occur on four or five mornings each month in May, June, and July, and average 21 days for the year. The highest number ever recorded in a month was twenty in June 1937.

Cloud and Sunshine

Cloudiness varies between a minimum in the summer months and a maximum in the winter, but the range like the rainfall is not great compared with many other parts of Australia. The number of clear days or nearly clear days averages two to three each month from May to August, but increases to a maximum of six to seven in January and February. The total number for the year averages 98. The high winter cloudiness and shorter days have a depressing effect on sunshine in winter and average daily totals of three to four hours during this period are the lowest of all capital cities. There is a steady rise towards the warmer months as the days become longer and cloudiness decreases. An average of nearly eight hours a day is received in January; however, the decreasing length of the day is again apparent in February, since the sunshine is then less in spite of a fractional decrease in cloudiness. The total possible monthly sunshine hours at Melbourne range between 465 hours in December and 289 in June under cloudless conditions. The average monthly hours, expressed as a percentage of the possible, range between 55 per cent. for January and February to 34 per cent. in June.

Wind

Wind exhibits a wide degree of variation, both diurnally, such as results from a sea breeze, etc., and as a result of the incidence of storms. The speed is usually lowest during the night and early hours of the morning just prior to sunrise, but increases during the day especially when strong surface heating induces turbulence into the wind streams, and usually reaches a maximum during the afternoon. The greatest mean wind speed at Melbourne for a 24 hour period was 22.8 m.p.h., whilst means exceeding 20 m.p.h. are on record for each winter month. These are mean values: the wind is never steady. Continual oscillations take place ranging from lulls, during which the speed may drop to or near zero, to strong surges which may contain an extreme gust, lasting for a period of a few seconds only, up to or even over 60 m.p.h. At Melbourne, gusts exceeding 60 m.p.h. have been registered during every month with a few near or over 70 m.p.h., and an extreme of 74 m.p.h. on February 18, 1951. At both Essendon and Aspendale wind gusts over 90 m.p.h. have been measured.

There have been occurrences of thunderstorms in all months ; the frequency is greatest during November to February. The greatest number of thunderstorms occurring in a year was 25. This figure was recorded for both 1928 and 1932.

Hail and Snow

Hailstorms have occurred in every month of the year; the most probable time of occurrence is from August to November. The highest number of hailstorms in a year was seventeen in 1923, and the greatest number in a month occurred in November of that year when seven hailstorms were reported. Snow has occasionally fallen in the city and suburbs; the heaviest snow storm on record occurred on 31st August, 1849. Streets and housetops were covered with several inches of snow, reported to be 1 foot deep at places. When thawing set in, floods in Elizabeth and Swanston streets stopped traffic causing accidents, some of which were fatal. One report of the event indicates that the terrified state of the aborigines suggested they had never seen snow before.

Victorian Weather Summary for 1962

Summer

December, 1961 and January, 1962 were generally warmer than usual, while February temperatures were well below normal. There were no exceptionally high temperatures recorded, although century readings occurred in many parts of the State late in December, in mid-January, and on 7th February.

The Central District suffered the worst bushfire outbreaks since 1939 between 14th and 16th January. This caused heavy stock losses, the destruction of homes, and property damage estimated at over £1 mill.

Conditions throughout the pastoral and agricultural industries were generally satisfactory at the end of the summer, most areas receiving useful rains in December and January, with substantial surpluses in the north-west. February was a fairly dry month.

The rainfall during summer was below normal in the Western and Central Districts, and the eastern part of the Central District had a deficit of 25 per cent. The southern Mallee had 80 per cent. more than the usual rainfall in the summer.

Autumn

The first part of autumn was dry in most parts of the State with above average temperatures. Prospects in the agricultural and pastoral industries were gradually deteriorating.

March and April were months showing almost general below average rainfall, with pronounced shortages in most districts. Good rains, however, fell during May with normal amounts in the Mallee, a little above average in other districts in the western half of the State, but marked surpluses in most of the eastern half, excesses exceeding 100 per cent. at places in the North-east and East Central Districts and East Gippsland.

Water supplies, which were very low, were replenished during May, but at the end of the autumn storages in many parts were still well below normal.

Mean maximum temperatures were well above normal during March and April and much below during May. There were no hot days during March, but there were some warm days in the last week of April, while during May temperatures were above average on only a few days and snow fell over a wide area in the Eastern Highlands during the fourth week. Mean minima were higher than usual in most parts during March, lower during April, and below average generally during May.

Several fire outbreaks occurred in the Central and Western Districts from the 22nd to the 27th April. The worst occurred in the Dandenong Ranges, near Yarra Glen, and on the Otway Peninsula. Other outbreaks were reported in the Grampians, Daylesford, between Casterton and Portland, and on the Mornington Peninsula. Although minor outbreaks, they were the worst since the fires in January, 1962.

Winter

The year's dry trend in Victoria continued into winter, because rainfall during these months was generally below normal throughout the State, except for the southern Mallee. The greatest departures were in the north of the Mallee and East Gippsland which district received only 60 per cent. of the normal season rainfalls.

The winter was a mild one, mean temperatures throughout the period being close to or above normal over the State, but these persisted for a few days only. The mildness of the season resulted mainly from a series of minimum temperatures above average for the greater part of the season. A cold outbreak at the beginning of August, together with a further cold break from 19th to 24th August, tended to reduce the mean maxima for this month to below normal. However, an extraordinary warm spell towards the end of the month counteracted this effect.

Exceptionally heavy falls of snow were reported in the highlands of the North-east and adjacent ranges on 21st and 22nd August. On 21st August, snow was also reported in the Western District, along the Great Dividing Range, and in East Gippsland at stations below the normal snow line.

Agricultural conditions were satisfactory at the end of the winter despite late seeding of cereals and slow germination of wheat at the beginning of the season. Although water supplies improved generally, further rains were needed to fill catchments and to provide more surface water.

Spring

Spring rainfall was below normal in the Mallee, Upper North, North-east, Gippsland, and East Central ; of these Districts, the greatest departure from normal was in the north of the Mallee where less than half the normal rainfall was received. In the rest of the State, spring rainfall was close to or above normal, being as much as 20 per cent. above average in the south of the Wimmera.

Minor flooding occurred in a few Melbourne suburbs on 24th September and 20th October.

October was the coolest of the spring months in 1962. In November, century temperatures or above were recorded at many places on 19th and 30th November, the highest reported being 110° F. at Ouyen.

Snow was relatively sparse this spring. It fell on the North-Eastern Highlands on 28th September, and again on 6th and 28th October and at Mount Macedon on 28th September and 6th October.

Several small bushfires broke out in the Dandenong Ranges, Gippsland, and the North Central District on 4th September. On Monday, 19th November, over 10,000 acres of land in the Central, Western, and Gippsland Districts were destroyed by scattered bush and grass fires.

Strong gusty winds prevailed over the State from 2nd to 5th September, and along the west coast, on 6th and 7th September. In Melbourne, a gust of 69 m.p.h. was recorded on the 4th September. This equalled the record for September established in 1948. Several gusts over 60 m.p.h. occurred during the afternoon and these winds damaged buildings and property and caused blackouts and resulted in the loss of one life.

The water storage position was aggravated towards the end of the spring by below normal rainfalls in the West Central, Mallee, and Gippsland Districts.

Meteorological Records

The above particulars about climate have been furnished by the Commonwealth Bureau of Meteorology, and some figures are given in the following tables. In the first is shown the rainfall for each district and for the whole State for each of the years 1953 to 1962, together with the average rainfall covering a period of 30 years :—

VICTORIA—RAINFALL IN DISTRICTS
(Inches)

Year	Districts							
	Mallee	Wimmera	Northern	North Central	North Eastern	Western	Central	Gippsland
1953	12·27	19·62	16·81	28·69	35·57	30·40	30·75	35·29
1954	13·41	17·68	21·22	29·88	35·58	25·92	30·93	34·02
1955	17·68	22·44	26·00	35·99	49·05	32·40	34·12	33·86
1956	20·85	24·31	31·45	41·17	55·59	34·02	34·29	44·25
1957	9·67	14·87	13·55	23·01	27·32	26·82	24·85	31·98
1958	15·45	17·65	21·40	31·57	37·78	29·05	28·99	35·42
1959	9·97	15·16	16·56	26·09	27·69	24·46	26·53	33·63
1960	18·08	24·75	22·70	38·45	40·16	36·01	34·98	37·26
1961	13·44	15·07	14·90	25·27	27·60	24·03	22·90	33·04
1962	11·29	17·69	18·85	27·77	33·78	25·99	26·07	31·41
Averages* ..	12·49	17·52	18·09	28·16	34·81	27·59	28·89	33·47

* Averages for a standard 30 years' period 1911–1940.

The heaviest rainfall in the State occurs in the Eastern Highlands (from the Yarra watershed to the Upper Murray), in the Cape Otway Forest in the Western District, and in the South Gippsland, Latrobe and Thomson Basin sections of the Gippsland District. The lightest rainfall is in the Mallee District, the northern portion of which receives on the average from 10 to 12 inches only per year.

The following table shows the monthly rainfall and mean temperatures for 1962 recorded in various Victorian country centres and is followed by a graph of the district monthly rainfall for 1961 and 1962 :—

VICTORIA—WEATHER CONDITIONS IN SELECTED VICTORIAN TOWNS, 1962

(Points : 100 = 1 inch)

Locality		Legend No.*	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
MALLEE ..	Mildura ..	1	252	10	30	1	156	26	37	112	16	43	7	326
		2	89·7	86·7	83·9	76·7	63·2	64·6	62·0	62·3	68·4	72·8	84·0	84·1
		3	64·6	58·7	51·3	48·7	43·3	44·3	40·0	43·1	44·3	49·5	54·8	58·6
	Ouyen ..	1	148	9	100	28	117	113	72	146	181	56	16	30·8
		2	90·9	86·7	84·3	76·6	63·1	63·2	61·4	61·0	67·5	72·3	84·1	85·0
		3	61·9	57·3	56·2	48·0	43·3	45·3	40·1	44·0	43·6	47·7	53·7	58·9
WIMMERA ..	Horsham ..	1	15	37	67	21	196	247	77	198	236	214	61	96
		2	89·4	84·5	81·5	74·5	60·8	60·0	57·9	58·4	64·3	65·8	77·8	82·7
		3	58·8	54·4	53·8	47·0	42·0	43·3	40·8	41·5	42·1	44·1	49·7	53·2
	Nhill ..	1	17	75	97	27	209	226	76	215	328	197	52	135
		2	89·1	83·9	81·1	73·9	61·4	60·5	58·2	58·7	63·1	65·3	78·2	81·0
		3	57·6	52·8	52·6	44·4	41·1	44·2	39·7	42·4	41·0	43·3	46·8	52·0
WESTERN ..	Ballarat ..	1	181	83	172	94	324	381	194	253	361	322	120	104
		2	80·4	76·1	74·0	67·3	54·5	53·4	52·0	51·8	57·4	59·0	67·5	72·8
		3	54·4	49·6	51·7	45·8	41·0	41·6	38·9	39·0	41·4	42·0	45·3	51·3
	Hamilton ..	1	66	116	222	62	279	388	145	220	242	292	87	110
		2	81·7	77·4	75·7	69·4	58·4	56·9	56·6	56·1	60·0	60·6	69·7	73·1
		3	55·4	51·6	52·7	48·3	43·6	46·0	42·3	42·9	43·4	43·7	46·9	51·6
	Warrnambool	1	44	123	178	128	467	464	224	329	218	416	99	128
		2	73·2	71·9	71·8	67·9	60·2	59·5	58·3	58·2	61·3	61·8	68·0	70·0
		3	56·7	54·4	54·4	50·8	45·8	46·6	44·4	43·6	45·6	46·1	49·2	53·0
NORTHERN	Bendigo ..	1	348	36	128	17	315	196	228	322	248	165	65	184
		2	84·3	81·0	79·3	72·3	58·0	56·2	55·1	55·4	62·0	63·8	74·3	79·3
		3	59·4	54·9	55·1	47·8	41·9	43·0	39·7	41·3	42·4	43·8	49·5	56·1
	Echuca ..	1	421	7	57	46	252	127	122	162	230	67	82	118
		2	87·9	84·1	82·8	75·1	60·9	59·5	57·1	59·0	65·8	69·1	79·7	83·9
		3	61·6	56·4	56·7	48·2	42·7	44·4	39·9	41·7	44·0	45·7	51·7	57·8

NORTH CENTRAL	Kyneton	1	224	95	212	88	568	386	308	306	281	440	77	159
		2	79·0	76·0	75·1	66·9	53·0	52·3	51·8	51·1	57·5	59·0	69·6	71·4
		3	52·5	47·9	48·6	41·2	38·6	40·5	36·2	36·9	39·4	39·7	43·4	49·0
	Rubicon	1	286	125	199	68	1,347	1,065	584	698	627	552	297	228
		2	75·4	72·7	72·0	63·7	48·7	46·4	47·3	45·9	52·2	53·7	64·2	69·0
		3	55·0	51·2	52·3	46·8	39·3	39·4	37·7	36·2	39·0	39·7	46·2	51·8
CENTRAL	Geelong	1	110	106	97	108	306	146	176	202	282	245	43	99
		2	76·6	73·4	75·0	68·7	60·3	61·1	57·7	58·0	62·0	63·3	69·6	73·6
		3	59·3	55·0	56·4	52·5	46·2	46·3	40·7	43·3	45·1	46·2	49·5	56·0
	Mornington	1	174	124	68	93	566	232	241	312	404	376	95	115
		2	78·2	75·5	76·4	68·2	58·5	57·5	55·3	55·9	59·8	60·8	67·8	72·9
		3	58·1	56·2	57·5	52·9	48·7	50·0	46·5	43·9	47·1	47·8	51·4	55·6
NORTH EASTERN	Wangaratta	1	250	22	259	214	440	265	196	360	249	202	144	236
		2	87·0	85·1	83·4	73·7	59·1	56·6	56·0	56·4	63·7	65·5	77·6	82·5
		3	60·7	55·9	53·6	45·7	41·0	41·7	37·8	39·6	42·3	44·3	49·9	56·8
	Omeo	1	352	72	84	216	348	111	84	247	263	370	164	526
		2	77·9	75·4	75·4	66·7	54·5	54·0	52·6	57·8	58·8	60·1	71·4	72·7
		3	50·3	48·2	44·8	36·6	35·3	36·2	29·5	32·5	37·5	37·2	41·3	47·6
WEST GIPPSLAND	Yallourn	1	274	226	76	86	365	309	292	446	442	264	127	302
		2	79·1	74·2	74·3	68·7	57·5	57·7	54·6	54·7	59·1	59·8	69·0	72·6
		3	56·9	53·9	54·5	49·3	44·8	45·4	42·6	41·5	44·9	45·1	47·5	53·2
	Wilson's Promontory	1	322	291	122	46	1,115	935	376	397	488	629	187	161
		2	70·5	66·8	67·4	64·2	57·0	57·1	54·0	53·9	56·5	57·2	64·6	66·3
		3	58·5	57·7	59·0	55·4	50·3	48·5	47·6	45·8	47·4	47·3	50·8	54·5
EAST GIPPSLAND	Bairnsdale	1	436	135	38	185	302	72	77	222	219	192	115	388
		2	77·6	75·0	76·0	70·4	62·2	63·7	60·6	59·6	63·8	64·7	72·0	73·6
		3	57·2	55·7	53·0	47·1	43·0	42·3	39·3	40·4	43·2	44·6	49·1	54·3
	Orbost	1	431	185	59	236	589	99	71	295	367	338	87	706
		2	77·4	74·6	76·7	70·7	62·7	63·1	60·3	59·2	63·8	64·5	71·4	75·3
		3	56·6	55·8	53·1	48·3	42·3	41·2	40·1	39·6	42·5	43·2	48·5	54·3

* Legend :—1. Total Monthly Rainfall. 2. Average Daily Maximum Temperature. 3. Average Daily Minimum Temperature.

VICTORIA—DISTRICT MONTHLY RAINFALL, 1961 AND 1962

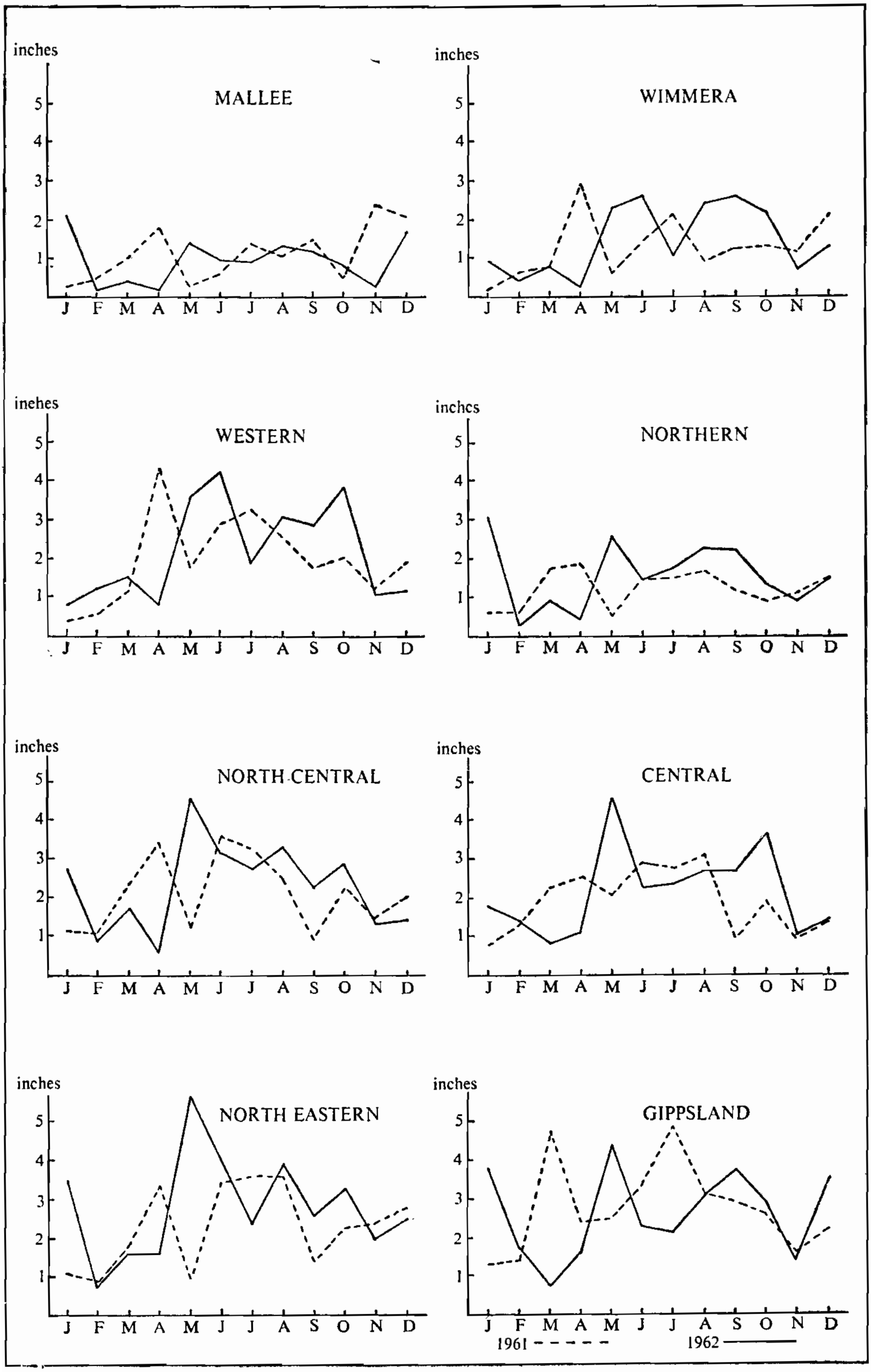


FIGURE 5.

The means of the climatic elements for the seasons in Melbourne deduced from all available official records are given in the following table :—

MELBOURNE—MEANS OF CLIMATIC ELEMENTS

Meteorological Elements	Spring	Summer	Autumn	Winter
Mean Pressure of Air (Inches)	29·971	29·920	30·075	30·076
Monthly Range of Pressure of Air (Inches)	0·889	0·763	0·816	0·973
Mean Temperature of Air in Shade (° F.) ..	57·7	66·7	59·4	50·1
Mean Daily Range of Temperature of Air in Shade (° F.)	18·7	21·1	17·4	14·0
Mean Relative Humidity (Saturation = 100)	64	59	69	74
Mean Rainfall in Inches	7·36	6·10	6·58	5·86
Mean Number of Days of Rain	40	25	34	44
Mean Amount of Spontaneous Evaporation in Inches	10·23	17·33	8·09	3·79
Mean Daily Amount of Cloudiness (Scale 0 to 8)*	4·8	4·2	4·7	5·1
Mean Number of Days of Fog	1	1	6	12

* Scale : 0 = clear, 8 = overcast.

In the following table are shown the yearly means of the climatic elements in Melbourne for each year 1958 to 1962. The extremes between which the yearly mean values of such elements have oscillated in the latter periods are also included.

MELBOURNE—YEARLY MEANS AND EXTREMES OF CLIMATIC ELEMENTS

Meteorological Elements	1958	1959	1960	1961	1962
Atmospheric Pressure (Inches)—					
Mean	30·015	30·080	29·996	30·050	30·010
Highest	30·522	30·669	30·570	30·620	30·594
Lowest	29·451	29·233	29·157	29·367	29·366
Range	1·071	1·436	1·413	1·253	1·228
Temperature of Air in Shade (°F.)—					
Mean	58·3	59·5	58·8	61·1	60·1
Mean Daily Maximum ..	66·6	68·8	67·6	70·4	68·6
Mean Daily Minimum ..	49·8	50·7	50·0	51·9	50·7
Absolute Maximum	101·7	109·0	105·0	107·0	104·0
Absolute Minimum	32·3	29·5	31·3	33·4	31·8
Mean Daily Range	16·7	18·4	17·5	18·5	17·8
Absolute Annual Range ..	69·4	79·5	73·7	73·6	72·2
Terrestrial Radiation Mean Minima (°F.)	46·8	47·5	45·9	48·2	47·3
Rainfall (Inches)	26·98	25·84	33·50	22·05	23·06
Number of Wet Days	155	131	162	129	140
Year's Amount of Free Evaporation (Inches)	38·75	38·43	41·44	42·17	43·21
Percentage of Humidity (Saturation = 100)	66	65	65	63	61
Cloudiness (Scale 0 to 8)* ..	4·8	4·6	4·9	4·4	4·5
Number of Days of Fog ..	21	24	21	18	9

* Scale : 0 = clear, 8 = overcast.

An estimate of the areas of the State subject to different degrees of average annual rainfall, and the actual distribution of rainfall in Victoria as shown by area for 1961 and 1962 is shown in the following table :—

VICTORIA—DISTRIBUTION OF AVERAGE AND ANNUAL RAINFALL

Rainfall (Inches)	Area (To Nearest 100 Square Miles)		
	Average	1961	1962
Under 10	Nil	Nil	82
10–15	197	194	102
15–20	134	224	148
20–25	157	223	330
25–30	158	126	150
30–40	142	92	40
Over 40	91	19	26