Part 1

PHYSICAL ENVIRONMENT

Mammals of Victoria

Introduction

In the animal kingdom there are five classes of vertebrates—that is, animals having backbones. These are classified in the phylum *Chordata*, which comprises the most highly evolved animals.

Fish (class *Pisces*) are aquatic and obtain oxygen by means of gills from air that is dissolved in the water. Amphibians (class *Amphibia*) have two distinct stages in the life history: first, they are gilled animals, such as the tadpole stage of a frog, then they develop lungs and breathe atmospheric air. Reptiles (class *Reptilia*), birds (class *Aves*), and mammals (class *Mammalia*) breathe air by means of lungs at all stages of their lives after birth.

Fish, amphibians, and reptiles are cold-blooded; their body temperature varies according to the heat or coldness of the surroundings. Birds and mammals are warm-blooded; when in normal health, their body temperature remains practically constant, irrespective of variation in surrounding conditions.

Reptiles have scaly skin, and the same characteristic is to be seen on the legs and feet of birds. Both birds and mammals possess a covering of material that tends to prevent escape of heat from the body. In the case of birds, the body covering consists of feathers; and in mammals it is fur. Mammals are often referred to, therefore, as the "furred animals", to distinguish the class from other groups of the animal kingdom.

In reproduction, the young of fish, amphibians, reptiles, and birds are hatched from eggs. When the eggs are laid before the young emerge, reproduction is said to be *oviparous*. This applies to most representatives of these four classes, including all birds. However, when the young hatch from the eggs within the body of the parent, and are then produced alive, as with many reptiles, the reproduction is said to be *ovoviviparous*. The vast majority of mammals are *viviparous*; there is no egg stage during embryonic development, and the young are produced alive and active. However, several mammal species, comprising the monotremes, are oviparous.

The term "fur" is used here in a comprehensive sense. The body covering varies greatly from species to species and, according to its texture, may be commonly referred to as wool, fur, hair, bristles, or quills.

A second feature which distinguishes mammals from all other animals, is the suckling of the young by the mother. In all mammal species the female produces milk in glands on the front or underside of the body, and this serves to nourish the young during the

earliest stages of growth after birth. The organs in which the milk is secreted are the *mammae,* and from this term the name mammal is derived.

Classification of Mammals

Living mammals are grouped into three major divisions : the monotremes or egg-laying mammals, the marsupials or pouched mammals, and the placental or higher mammals. The Australian region is the only part of the world where representatives of all three groups occur naturally. Moreover, because Australia has been isolated for so long from the great land-masses of the world, there survive in this country certain kinds of mammals which seem to indicate some of the early steps by which the class was evolved from ancient reptile groups.

Egg-laying Mammals (Monotremata)

These number only about six species : the platypus and several kinds of echidna. They are the most primitive present-day mammals, and many of their characteristics are reptilian.

Monotremes are the only mammals that are oviparous ; reproduction is by means of shell-less leathery eggs, similar to those of a tortoise or lizard. Certain features of their brain and bone structures also are reptilian rather than mammalian. Body temperature of monotremes is not as well regulated as in other warm-blooded animals. For instance, whereas a man's temperature varies only about ½° F. from the average (98·6° F.), that of a platypus may fluctuate, according to surrounding conditions, as much as four degrees on either side of the mean.

The mammary glands of monotremes do not have single openings or nipples as in other mammals. Instead, milk exudes through a number of large pores in the breast area, and the young lick the fluid from the skin or fur.

The platypus lays eggs in a nest, as birds do ; echidnas develop folds of abdominal skin, to form a rudimentary pouch, in which the egg is carried and in which the young one remains during the early stages of its growth. When the young one is no longer carried about by the parent, the " pouch " of the echidna disappears.

Pouched Mammals (Marsupialia)

These number about 200 species. The group name is derived from the Greek *marsupion*, meaning " pouch ", and it alludes to the development of a recess in which the young are carried after birth. In small insectivorous marsupials, such as phascogales, there is no true pouch but merely an area with nipples to which the young cling. With these animals, the " pouch " is hardly more developed than that of an echidna. More highly developed pouches occur in other marsupials, the nipple area being almost completely enclosed by skin and fur. With kangaroos and possums, the opening of the pouch is at the top or front, but with wombats, koalas, bandicoots, and dasyures, the pouch opens to the rear.

Despite the derivation of the name, the possession of a pouch is of minor significance, auxiliary to the fundamental characteristic of the marsupial. What really distinguishes the sub-class is the nature of embryonic development. There is a very short period of gestation, with little or no nourishment of the embryo during its growth. Only the bandicoots (family *Peramelidae*) have a fairly well-developed placental connexion, but in general the embryonic development of a young marsupial involves very little in the way of nourishment from the parental tissues. Therefore the young are born at a very early stage of development. A new-born kangaroo, for instance, is little over an inch long and weighs about a quarter of an ounce. Eyes, ears, and fur are lacking, and the tail and limbs are little developed.

Nevertheless, young marsupials are active immediately after birth ; they use their tiny fore-limbs to scramble to the parent's pouch, where they seek a nipple and take hold of it. The nipple swells in the mouth, so that the tiny animal is tightly attached. In many cases, the number of young which are born exceeds the number of nipples for their accommodation, and the excess young ones must perish.

After attachment, the young lose all power of movement and they are force-fed by milk expressed from the nipples. Gradually they grow ; organs such as ears and eyes develop ; fur appears ; and they regain the ability to move. At this stage, their development is about equivalent to that of a newly-born placental mammal—they may let go the nipple and return to it at will, and they eventually learn to leave the pouch and to get back into it as circumstances warrant. When too large to enter the pouch, a young marsupial will nuzzle into it for a drink of milk, until finally it is weaned.

Placental Mammals (*Monodelphia*)

These number many thousands of species. They are often referred to as the higher mammals, and they comprise seventeen of the nineteen orders of present-day mammals. During the development of the embryo in the higher mammals, the placental connexion provides for the transfer of nourishment from the parent's blood-stream to the unborn young. Compared with the marsupials, a much greater development of the embryo is therefore possible, and at birth a placental mammal may weigh as much as one-twentieth the adult's weight. Eyes, ears, and limbs are quite well developed.

Distribution of Mammals

As regards populations of native mammals, Australia is unique amongst the large countries of the world.

Monotremes

The monotremes are confined to the Australian region (which includes Tasmania and New Guinea). These primitive mammals may represents a very early evolutionary offshoot from a reptile group originally distributed in other parts of the world. Alternatively, the monotremes may have evolved originally in the Australian region, after it was separated from other land-masses. In either case, the survival of

the few species of the order in this part of the world is evidently due to their isolation from the competition of great numbers of species of placental mammals such as inhabit other continents.

Marsupials

Although the marsupials are also a primitive order of mammal, they are much more advanced in evolution than the monotremes. There are nine families of marsupials, and these are divided in distribution between the American and the Australian regions. The American species comprise two families (*Didelphidae* and *Caenolestidae*), which include the original opossums. The other seven families are Australian: dasyures (*Dasyuridae*), numbat (*Myrmecobiidae*), marsupial "moles" (*Notoryctidae*), bandicoots (*Peramelidae*), possums and koala (*Phalangeridae*), wombats (*Phascolomidae*), and kangaroos (*Macropodidae*). Five of these are represented in Victoria, the exceptions being the numbat and marsupial "mole". The order was once more widely distributed in the world than it is today, and the occurrence in the Australian region of such a large proportion of the marsupials which survive is again due to the long isolation of this country from other continents with their numerous placental mammals.

Placental Mammals

The evolution and spread of the placental mammals took place after the isolation of the Australian region. Therefore the mammal fauna of this area has remained very distinct from that of Asia and Indonesia. Groups which are otherwise widespread but which did not reach Australia naturally, include elephants, horses, and rhinoceros, as well as deer and cattle.

Of the order *Primates,* only one representative—man—is native to Australia. No monkey or any member of the several other families of the *Primates* reached the region naturally. When some of the ancestors of the Australian aborigines crossed the seas to this continent, they brought with them domestic dogs. These became the progenitors of the dingo. Thus a single species of the dog family (*Canidae*) is the sole natural representative in Australia of the order *Carnivora,* and no bears (family *Ursidae*) or cats (family *Felidae*) for instance, reached this country before its discovery by Europeans.

Bats (order *Chiroptera*), which developed the power of flight, were able to migrate across seas. About 40 species, representing seven of the world's seventeen families of bats, are found on the mainland of Australia.

During the evolution of mammals, three marine orders developed, and Australian waters acquired representatives of each. Whales and dolphins (order *Cetacea*) are widely distributed; the dugong or sea-cow of northern Australia belongs to the order of sea-sirens (*Sirenia*); and there are several species of seals (order *Pinnipedia*) about the south of the continent.

The only other native Australian placental mammals are rats and mice, which belong to a family (*Muridae*) of the rodents (order *Rodentia*). Although about 80 species of rats and mice are dealt with in recent lists of Australian mammals, critical revision would probably fix the number of valid species at about 40. Nevertheless, there are many kinds of native rats and mice in Australia. The ancestors of the local rodent species evidently reached the Australian mainland and neighbouring islands on floating debris, such as logs and trees carried out to sea by floods. Such fortuitous migrations must have occurred many times, to provide the wide variation in the native murid population. Typical rats (genus *Rattus*) are represented by close relatives of oversea species; but there are also some characteristically Australian murids. The genus *Pseudomys* and its relatives comprise a group which is confined to Australia. Its original stock must have reached Australia a long time ago, as there has since been a period sufficient for members of the group to die out elsewhere in the world, or alternatively for marked evolutionary changes to take place in the Australian animals.

Prehistoric Australian Marsupials

Fossil remains, in many localities of mainland Australia, Tasmania, and New Guinea, show that in bygone ages there were many more marsupial species in this region than there were at the time of the discovery of Australia by Europeans. Moreover, there were species much larger in size than any present-day marsupials. All or most of these giants were herbivorous, and the abundance of large plant-eating marsupials was accompanied by a development of large flesh-eating species. Radical changes in climatic conditions and in vegetation have been accompanied by the gradual extinction of many marsupials, including all the giant herbivorous species. On the mainland, the large carnivorous species (*Thylacinus* and *Sarcophilus*) died out too, though each survives in Tasmania.

The mainland race of aborigines is thought to have reached Australia between 15,000 and 20,000 years ago, and the Tasmanian race may have been in occupation long before that. It is certain that these people contributed to major changes in the composition of the fauna of Australia, directly by hunting and indirectly as a result of other activities.

The dingo, brought by the aborigines, may also have caused some change, both by preying upon plant-eaters and by competing with flesh-eaters.

Changes Since European Settlement

During the 175 years that have elapsed since the founding of Sydney, the Australian countryside has been greatly changed in many ways, and this has had a drastic effect on the native fauna, especially on the mammals. Areas of heavy forest were cleared for intensive farming, particularly on alluvial soil along streams. Tracts of natural grassland and lightly forested areas were cultivated for

the growing of cereals, and much of the remainder of the country was used for the grazing of vast flocks and herds. All this reduced the living room of the native mammals, and their numbers decreased in proportion. Many species were hunted extensively for their skins or killed because they interfered with the livelihood of the settlers. Furthermore, the practice of burning off and firing the countryside for other purposes, produced innumerable casualties amongst the fauna.

Apart from domestic and farm animals, many alien mammals were introduced and liberated in Australia. Of these, the rabbit (*Oryctolagus cuniculus*) and the fox (*Vulpes vulpes*) in particular, have had dramatic effects on the native mammal population. The rabbit spread in millions throughout the country and denuded the ground of much of the natural herbage upon which the grazing and browsing marsupials depended. The fox preyed upon small animals and exterminated many of them from large tracts of country. Moreover, diseases were brought to Australia with animals from overseas, and epidemics decimated populations of a number of native species.

As a result of these factors, the mammals of Australia have been reduced, during the past 150 years, to a small fraction of what they were originally, and a few species have become extinct altogether. As Victoria is the most densely populated State of the continent, its native fauna has suffered more than that of other States.

The Red-bellied Pademelon (*Thylogale billardieri*) was originally plentiful across southern Victoria; the Rufous Rat-kangaroo (*Aepyprymnus rufescens*) was to be found in northern and north-eastern districts; and Gaimard's Bettong (*Bettongia gaimardi*) was in central and eastern Victoria. These three have been gone from this State for 60 years or more. Furthermore, evidence in cave deposits indicates that both the Brush-tailed Bettong (*Bettongia penicillata*) and Lesueur's Bettong (*B. lesueur*) originally occurred in Victoria, but it is not known at what stage these disappeared.

The advent of the European fox has been a major factor in the decimation of small members of the kangaroo family. It was evidently the final factor in the elimination from Victoria of the pademelon, and it has been mainly responsible for the near annihilation of the potoroo (*Potorous tridactylus*) and of the rock-wallaby (*Petrogale penicillata*).

During the past several years, a number of deposits of small mammal bones have been found in both eastern and western Victoria. These have shown that several species of pseudo-rat (including *Pseudomys oralis* and *P. auritus*), one species of small native mouse (*Gyomys novaehollandiae*), and a species of *Thetomys*, none of which were recorded for Victoria, had in fact occurred very recently in the State. Moreover, some species which are now extremely rare—Smoky Mouse (*Gyomys fumeus*) and Broad-toothed Rat (*Mastacomys fuscus*)—had been widely distributed. Likewise, a rabbit-rat (*Conilurus albipes*), extinct since last century, had been widespread in Victoria.

Common Names for Native Mammals

The problem of suitable common or popular names for Australian mammals is considerable. Early explorers and colonists often named them according to oversea groups to which they bore general, or even only slight, resemblance. Thus the names of placental mammals, such as wolf, bear, porcupine, cat, and mouse, were given to marsupials or monotremes. Some of these have been superseded, but others, unfortunately, are still more or less current.

Scientists and naturalists have from time to time endeavoured to rectify this state of affairs, but many of their published suggestions have been too cumbersome for popular use. Occasionally, short euphonious names appear, and many of these are being publicized, to encourage their adoption as common words in our language.

Egg-laying Mammals

Echidna

The echidna (*Tachyglossus aculeatus*) is quite abundant in Victoria, and it is widely distributed over Australia. It is the sole mainland representative of the family, though there are other species of echidna in Tasmania and New Guinea. The echidna's body-covering is a mixture of bristles and quills, and the latter range from slender to very stout. The snout is long and slender ; the tongue is slender, too, and extremely long. Feet are stout and heavily clawed, for burrowing. An echidna digs into an ants' nest, nuzzles into the tunnels which swarm with the agitated insects, then exserts the slender sticky tongue and takes in scores of ants at a time. In natural conditions, echidnas feed solely on ants. These are ground up between the palate and horny plates on the rear of the tongue, for an echidna has no teeth.

For protection, an echidna digs into the earth, pushing the soil outwards and literally sinking down until it eventually disappears from sight. If rolled over before it has a chance to dig in, the animal folds its head and limbs inward and protects its soft underparts with an array of quills.

After the egg hatches, the baby echidna is carried in the mother's rudimentary pouch until it is too large to be retained there. The young one is coarsely haired, and quills do not appear amongst the hairs until it is quite large.

Platypus

The platypus (*Ornithorhynchus anatinus*) is the sole species of its family. The body is softly furred, though the tail has long stiff hairs ; and the skin of the lips is adapted into a leathery bill like that of a duck. The platypus also lacks teeth, but there are bony plates on the jaws for crushing the aquatic animals which it catches for food. The front feet are strongly clawed for digging, and also webbed for swimming. The web can be spread beyond the claws, but it is folded inward when the animal is burrowing. The male has a strong spur on each hind leg, and this is connected to a poison gland.

A family of platypuses lives in a burrow near the water, and the female builds a nest of grass and leaves in a terminal chamber. Two or three eggs are laid, and the young are reared in the nest.

The platypus is quite plentiful in Victorian streams, in places where there is a certain amount of vegetational cover along the banks. Though the animals feed mainly at night, they may be encountered occasionally in secluded places during the day.

Families of Australian Marsupials

Main Groups

Pouched mammals of the Australian region are classified into three natural groups, which may be distinguished by characters of the feet and of the teeth.

The feet may be *diadactylous* or *syndactylous*. The former condition occurs when all digits of the hind foot are separate. In the syndactylous groups, the second and third digits of the hind foot are united for most of their length within a single sheath or skin, so that there appears to be a toe with two nails.

In dentition, our marsupials are either *polyprotodont* or *diprotodont*. Polyprotodont means, literally, " many front teeth ", and it refers to the number of incisors (6, locally) in the lower jaw. Diprotodont means " two front teeth ", and this alludes to the pair of large lower incisors which project forward, more or less in line with the jaw, whilst other lower incisors are minute or absent.

The first group is represented in Victoria by the family *Dasyuridae*, whose members are diadactylous and polyprotodont. Being mainly carnivorous, they have sharply cusped, cutting molars.

Secondly, there is the family *Peramelidae*, which are syndactylous and polyprotodont. Though the canines are well developed, the molars are low-cusped for grinding, indicate an omnivorous diet.

The third group comprises three local families : the *Phalangeridae*, *Phascolomidae* and *Macropodidae*. All these are both syndactylous and diprotodont. Teeth are modified for a herbivorous diet ; canines are lacking from the lower jaw and are reduced or absent from the upper jaw, while the molars are broad and low-cusped.

Dasyures (*Family Dasyuridae*)

Members of this family fall into three distinct groups or sub-families. Two of these groups occur in Victoria : the so-called " native cats " (*Dasyurinae*), which are true flesh-eaters, and the smaller species (*Phascogalinae*), which are mainly insectivorous.

The tiger-cat (*Dasyurops maculatus*) is the size of a large domestic cat, but the legs are short in proportion. Both body and tail are long, and are brown in colour with large rather irregular light spots. The natural food of the tiger-cat comprises small native mammals and birds, but now rabbits are probably the main fare. Until quite recently, the species was considered to be rare, but during the past

years, it has come to notice in widely separated localities in southern and eastern Victoria. Occasionally a tiger-cat enters a fowl pen and kills a number of birds, but more often one is caught in a rabbit trap.

Somewhat smaller, is the quoll (*Dasyurus quoll*)—recognized by its unspotted, rather bushy tail. Originally, the quoll was very abundant in most parts of Victoria but, about 1902, an epidemic almost completely eliminated it. Colonies persisted for a few decades in scattered localities, particularly in rough basalt country near Lake Corangamite in the Western District. Whether the species still survives in Victoria is not certain. Quolls lived in dens, to which they carried or dragged their prey and probably also many things which they found dead.

Largest of the phascogale group is the tuan (*Phascogale tapoatafa*). It somewhat resembles a large grey rat, but the tail is clothed, except at the base, with long black spreading hairs. The result is striking : a dark bottle-brush as wide as the animal's body. Tuans hunt in trees, systematically exploring crevices, removing loose bark and rotting wood, and rather noisily crunching the beetles and other insects that they secure. Occasionally they attack and kill larger prey, including roosting fowls in their pens. Because this last depredation brings the tuan to notice, it has the name of being a bloodthirsty killer. However, in its natural habitat it is, like the rest of the sub-family, practically completely insectivorous.

The Dusky Phascogale (*Antechinus swainsonii*) has the appearance of a small rat, but its long pointed snout and very short ears are shrew-like. It inhabits the forest areas of southern Victoria. The Tasmanian Phascogale (*Antechinus minimus*) is similar in general features, and is to be found in tussocky swamp country near Portland.

The Yellow-footed Phascogale (*Antechinus flavipes*) ranges from the Portland district and the Grampians, across the drier forest areas of northern Victoria. It has a grey head and the flanks and underparts are rufous. In southern and eastern districts, there is a smaller animal with uniform colouration. It is *Antechinus stuartii*, and Brown Phascogale is a suitable vernacular name for it. The latter is very abundant, inhabiting coastal scrubs, heavy mountain forests and woodlands.

Phascogales fossick about for insects on the butts of large trees, about logs and amongst leaves and other debris on the forest floor. Their hind limbs spread widely and they move with characteristic jerkiness. When disturbed, they take cover with lightning-like rapidity.

The mouse-sized members, of the genus *Sminthopsis,* favour open country and are more terrestrial in habitat than the species of *Antechinus.* Therefore the rough pads of the soles of the hind feet are much reduced in *Sminthopsis.*

The Fat-tailed Dunnart (*Sminthopsis crassicaudata*) is a short-tailed animal, quite plentiful about the plains of northern and western Victoria. It makes its home under a stone, in a log, or even in a crevice in the hard earth. It feeds on insects and other small terrestrial animals and, in times of plenty, its tail becomes quite swollen with a store of fat.

Little is known of the other two species of Sminthopsis which are recorded for Victoria. These are the dunnart (*Sminthopsis murina*) and the White-footed Dunnart (*Sminthopsis leucopus*), both of which are mouse-like in appearance, with the tail long and slender. Each has been recorded during recent years from the Portland area, and the latter also from the Otway Ranges.

Phascogales and dunnarts make nests of grass, leaves and shredded bark, in rock crevices, logs and tree-trunks. According to the number of nipples present, the females are able to rear many young at a time. Twelve may be carried by some small phascogales of the genus *Antechinus.*

Bandicoots (Family Peramelidae)

The Victorian bandicoots grow to the size of a small rabbit. The tail is very short and the snout particularly long. Their feet are very like those of small members of the kangaroo family, but the claws of the fore-paws are long, stout, and almost straight.

The animals find food by scent; their keen sense of smell enabling them to locate insects some inches down in the ground. Front claws and snouts are forced down into the soil so that usually, when the food has been extracted, a neat conical hole is left without any earth being scratched back. However, when a beetle or grub is deep in the soil, an excavation is made and earth thrown back and to the sides. Bandicoots take some vegetable matter also, and animals such as lizards. A nest of grass is made under a large tussock or dense shrub. In it the bandicoot rests during the day, and then comes out to forage at dusk and during the night.

The Short-nosed Bandicoot (*Isoodon obesulus*) is widespread in southern districts of Victoria, from Mallacoota to Portland and the slopes of the Grampians. It favours sandy soil with a covering of bracken and shrubbery, and it is prevalent near the coast. Its range includes remnants of the bayside heathlands of Melbourne's south-eastern suburbs. The term " short-nosed " is comparative; the nose is actually quite long but is much less so than in the following genus.

There are two Victorian representatives of the genus *Perameles,* the long-nosed bandicoots. One is an animal of the grassy plains and, like many species of that habitat, its numbers have been greatly depleted by extensive cultivation of grain crops and the improvement of pastures for sheep grazing. It is the Barred Bandicoot (*Perameles gunnii*), so-named because of the broad bands of lighter colour across the back. The species is still to be found in the Colac district and at Hamilton in western Victoria.

The Long-nosed Bandicoot (*Perameles nasuta*) is an animal of forested hill country. It is quite abundant about the mountains of southern and eastern Victoria, and the deep narrow conical holes which evidence its foraging may be seen amongst the grass on floors of small valleys and about the debris beneath huge forest eucalypts.

Bandicoots sniff audibly as they search for their food and, when disturbed, they make a short explosive snort. In defence, as well as biting, they jump at an enemy and strike with the long claws of the hind feet.

Possums and Koala (Family Phalangeridae)

These animals may be referred to collectively as phalangers, though this family name is more often applied popularly to gliders. Members of the family sleep during the day, mostly in hollows of tree-trunks and limbs, and they come out to feed at night.

Of all groups of native mammals in this State, the phalanger family has been least affected by European occupation of the country. All twelve of the original Victorian species still survive here, and two of them have even adapted themselves to densely settled areas.

The brushtails (genus *Trichosurus*) are the biggest possums. They are the size and build of a large cat, and their claws are strong and very sharp, for climbing. The tail, too, is adapted for the same purpose ; though bushy, it is prehensile and has an area of bare skin on the inside towards the tip, to ensure a good grip.

Our common brushtail possum (*Trichosurus vulpecula*) occurs throughout Australia, and there are distinct varieties in different districts. The Victorian race is known as the silver-grey, because of its colour in this locality. As well as living in hollow trees, silver-greys often occupy caves and crannies in rock outcrops, or even rabbit burrows. In built-up areas, they live in places such as lofts of sheds and above the ceilings of houses. They eat a variety of vegetable foods in the bush, and they will feed upon garden shrubs and orchard fruit as well.

The bobuck (*Trichosurus caninus*) is a larger species, with shorter ears and a less bushy tail. In central Victoria it is grey in colour, whereas in the east of the State the animal is almost black. Bobucks inhabit the heavy mountain forests but may be found in some cases in less dense forests of bordering areas.

Ringtail possums (genus *Pseudocheirus*) are of medium size, and in most species the tail is white for the apical one-third and it is not at all brushed. The common ringtail (*Pseudocheirus peregrinus*) is found throughout Victoria, favouring forest areas with dense undergrowth. In some districts the animals live always in hollows of trees, but in the scrub by lowland creeks and along the coast they make large domed nests of sticks and ferns. These are in tall shrubs, usually well out of reach, and a family of three or four ringtails may be in occupation. Like the silver-grey, our common ringtail has learned to live in town and city surroundings.

Of all Victorian mammals, Leadbeater's Possum (*Gymnobelideus leadbeateri*) has the most interesting history. It was originally discovered in 1867, in South Gippsland, and when, in 1909, one was collected in the Omeo district, there was a total of only five specimens known to science—all from eastern Victoria. There was

no further record of the animal for over 50 years, and it was presumed to have become extinct. Then, early in 1961, the animal was rediscovered near Marysville, about 70 miles north-east of Melbourne. In the heavy mountain forests of that district, the little possum is quite plentiful over at least several miles of country. Leadbeater's Possum is about 6 inches in body length and its tail is slightly longer. It is exceedingly active and sure-footed, both on tree-trunks and high amongst the twigs, and it jumps readily over distances of several feet. Little is known of the natural food of the species, but it probably feeds on nectar from blossoms and insects such as moths.

Pigmy or " dormouse " possums (genus *Cercartetus*) are not much larger than mice. They favour dense scrubby vegetation and build leaf and bark nests in hollows. Sometimes they use the deserted homes of ringtails or similarly massive birds' nests. Probably nectar is the main food of pigmy-possums, with insects a supplementary item of diet.

The common pigmy-possum in Victoria is *Cercartetus nanus*. It is bluish-grey in colour and, when food is plentiful, the basal half of the tail becomes very swollen with a storage of fat. The species is abundant in scrubs along the coast, and it is scattered in the lightly forested hill country of the State.

In the semi-desert of north-western Victoria, there is a smaller species of pigmy-possum. It is a warm red-brown colour on sides and back, and its tail does not become thickened. The technical name of the animal is *Cercartetus concinnus*, and it extends to Western Australia where the aboriginal name " mundarda " is applied to it.

The glider-possums form one of the most interesting groups of marsupials. From fore-leg to hind-leg, along each side of the body, there is a fold of loose skin and fur which stretches taut when the four limbs are spread out. By this means, the animals are able to travel through the air in long swooping glides. They take off from a limb or the trunk, high in one tree, glide down at an angle, and land on another tree. Sufficient control is exercised to swerve around obstacles and to bank for a gentle landing at the end of the flight.

The Dusky Glider (*Schoinobates volans*) is about the size of a ringtail, and its head is much the same, too ; but the glider's tail is very long and is clothed with dense spreading hair. The usual colour of head, back, and tail is jet black, and the underparts are white. The division between the two colours is along the edge of the gliding membrane, which stretches from " ankle " to " wrist ". However, specimens may be encountered with much of the normal black replaced by light-grey or white.

Dusky Gliders are quite abundant in the heavy forests of Victoria, where they feed upon the foliage of eucalypts. Occasionally, people are startled by the call which the species makes—a long drawn-out gurgling shriek giving way to a bubbling sound. This remarkable call is evidently made by one animal as it glides, so that its mate is aware of the direction it has taken.

In *Petaurus,* the gliding membrane stretches from " ankle " to the fifth digit of the fore-paw, and there are three species of this genus in Victoria. The Fluffy Glider (*Petaurus australis*) is not much smaller than the Dusky Glider. It is yellowish underneath and brown above, with a broad dorsal stripe. The tail is long and dark for most of its length, and the four limbs are blackish, too. These animals have the habit of chewing large patches of bark from such trees as Manna Gum (*Eucalyptus viminalis*) and Apple Box (*Eucalyptus bridgesiana*), both to extract insect larvae and to obtain sweet sap from the inner layers. In some cases, large trees are found with bark removed in a regular pattern from the whole length of the trunk. Fluffy Gliders are scattered across southern Victoria, in rather open forest, and they extend into the mountains to quite high elevations. They have a call something like that of the Dusky Glider.

The Squirrel Glider (*Petaurus norfolcensis*) inhabits open forests of north-central Victoria, and it may be elsewhere in the State. It measures about 2 feet from nose to tail-tip, the general colouration is light-grey with a dark dorsal stripe and white underparts. The hair of the tail is so long that the organ appears to be as wide as the body.

The Sugar Glider (*Petaurus breviceps*) is very similar to the Squirrel Glider, but it is smaller and the tail is not as broad in proportion to the body. Numbers of them nestle together in the hollows of trees, and at night they move out to feed on nectar and insects. They catch moths amongst the foliage or gouge larvae from the bark of trees. These little animals are very agile, their sharp claws enabling them to scamper about on vertical tree-trunks, and their gliding membranes facilitate short jumps or long glides from tree to tree. When alarmed, a Sugar Glider crouches flat against a tree-trunk or limb and calls " wok . . . wok . . . wok . . ." at intervals, like a young terrier yapping. The anger call is a prolonged snarl, something like the sound of a high-pitched starter-motor. In Victoria, this glider is widespread, its habitat ranging from the woodlands to the dense mountain forests.

The feathertail (*Acrobates pygmaeus*) is small enough to curl up in a matchbox, with room to spare. Its tail is not long-haired as in the other gliders, but has a row of stiff hairs on each side, giving the impression of a long narrow feather. The little feathertails are quite plentiful throughout Victoria, but because of their small size and nocturnal habits, they are rarely observed.

The largest phalangers, such as the brushtail possums, have a single young one at a time, medium-sized species usually have two ; and the pigmy members of the family may produce four or more.

Most popular of all marsupials is the koala (*Phascolarctos cinereus*). It is a unique species from the scientific point of view and, because of past uncertainty as to its affinities, it has usually been regarded as constituting a separate family. However, it is now grouped in the possum family.

The koala is larger than any possum, and it differs markedly in the absence of a tail and the backward-opening pouch. Both digits and claws are strong, to ensure a firm grip at rest and when climbing, for the koala is almost completely arboreal. It feeds upon the mature leaves of a few species of eucalypts of which the Manna Gum (*Eucalyptus viminalis*) is favoured in Victoria. Our popular name for the animal is said to be an aboriginal word meaning " non-drinker ", for the koala has learned to do without water.

Originally, koalas were abundantly distributed from eastern Queensland, through New South Wales and Victoria, to the border of South Australia. During the course of a century, the species was almost exterminated. Factors responsible were destruction of food trees during clearing operations, shooting for skins, bushfires and epidemic diseases. Very few koalas were left in Victoria by 1930, but a very effective rehabilitation programme has since been carried out by the State's Fisheries and Wildlife Department. As a result, there are now several thousand koalas, distributed widely, in Victoria.

Wombats (Family Phascolomidae)

The common wombat (*Phascolomis mitchellii*) is a large, sturdily built animal, with short broad head, short limbs and strong claws. It inhabits forest country, where it burrows deep into the hillsides to provide itself with a home.

Wombats crop coarse vegetation, and they often dig over many square yards of ground to obtain roots of shrubs and rhizomes of certain grasses. Occasionally, they bare the roots of trees and remove areas of bark, to lick the sweet sap from the growing wood.

Because they breach wire-netting of rabbit-proof fences round farm properties, wombats are placed in the same category as the introduced rabbit and fox. These are classed as " vermin ", and it is the duty of landholders to endeavour to eradicate them from their holdings. Were the country rid of rabbits, there would be little need to construct expensive netting fences and the wombat could be reclassified as a legally protected animal. The teeth of a wombat are like those of a rabbit ; they grow continuously from a basal pith, and it is necessary for them to be kept worn down. To accomplish this, wombats may periodically chew the fibrous bark of stringybark eucalypts. Wombats are found in most of the forested parts of Victoria. They range from the coast to the tops of Victoria's highest mountains, where, in winter, their tracks may be seen in the snow.

Kangaroos (Family Macropodidae)

Members of the macropod or kangaroo family are Australia's grazing animals. Mainly according to size, they are called such names as kangaroos, wallabies, wallaroos, and rat-kangaroos. The term " macropod " literally means " large foot ", and it refers to the great development of the hind feet, upon which kangaroos progress in a series of leaps.

Though the fore-limbs are comparatively small, they are stoutly built, with five strongly clawed digits. When the large kangaroos and wallabies graze, they creep along by alternately supporting the body upon tail and fore-paws while the hind-limbs are placed forward, then on the hind-limbs while tail and fore-limbs are moved forward. Small wallabies and rat-kangaroos do not use the tail as a support when creeping along, but take short leaps instead, now and again putting fore-paws to the ground even when scampering along quite fast.

The Grey Kangaroo or forester (*Macropus major*) is widespread and abundant in Victoria, mainly in the lowlands but occasionally quite high in the mountains. The animals rest during the day, in the shelter of trees and shrubs, and come out at night to graze in open grassy areas. If the weather is dull and misty, kangaroos may be seen grazing during the day.

When a family of kangaroos is attacked by dogs, the male or " old man " often remains to fight while the others seek refuge in flight. In his defensive stance—on toes and tail-tip—he may be as much as 7 feet tall. From this position, he endeavours to grasp an attacking dog with his fore-limbs and then strike with the hind-limbs, while momentarily balanced on his tail. In this way, using the large toes of the feet, a kangaroo can disembowel a dog. When hard pressed, a kangaroo or large wallaby may take to a lagoon or creek. As it stands at bay, in a few feet of water, it has the advantage of its attacker, and it may grasp and drown a dog which ventures to swim out to it.

The Red Kangaroo (*Macropus rufus*) is an animal of the inland plains. It is abundant enough in western New South Wales to constitute a serious problem to pastoralists. However, in Victoria it is not common, being restricted to the lower River Murray district and adjoining Mallee areas. The male is the reddish animal, whereas the female is bluish-grey.

The wallaroo (*Macropus robustus*) is almost equal in size to a large kangaroo, but it is more stockily built, with short limbs to suit its rocky habitat. The species has been recorded in Victoria once only, when two specimens were obtained in mountainous country near the Snowy River in north-eastern Gippsland.

In areas of moderate to high rainfall, where there is dense vegetation, the Swamp Wallaby (*Wallabia bicolor*) abounds. It thrives alike on treefern-clad mountain-sides, on swampy tea-tree flats and amongst vigorous growths of bracken. In keeping with this sombre habitat, the animal is of a general dark-brown colour with black tips. It is sometimes referred to as the Black-tailed Wallaby or simply the Black Wallaby.

Victoria's second wallaby has an even greater variety of common names. Officially it is the Red-necked Wallaby (*Wallabia rufogrisea*), but " Brush Wallaby " is widely used too. It favours areas of rather sparse vegetation and is equally plentiful in the open forests of the lowlands and amongst the snow-gums (*Eucalyptus pauciflora*) of sub-alpine plateaux.

Originally, the Brush-tailed Rock-wallaby (*Petrogale penicillata*) was extremely abundant about rock outcrops in eastern Victoria, from the Buchan district to the vicinity of Omeo and the upper River Murray area. Numbers were drastically reduced by hunters who shot many thousands for their pelts, and the coming of the fox accelerated their demise. From about 1917 onwards, it was thought that rock-wallabies had gone completely from Victoria, but twenty years later a colony of them was found overlooking the Suggan Buggan valley in north-eastern Gippsland. Further investigation has revealed that the species survives in about ten small areas of rocky escarpment and river gorge in the Snowy River valley. The habitat is evidently restricted to places where the wallabies can elude foxes.

The local rock-wallaby stands about 18 inches high ; it is grey in general colouration, with black feet and reddish flanks ; and the tail carries a brush of long hair.

Of the several smaller macropods which formerly inhabited Victoria, only one survives—the potoroo (*Potorous tridactylus*). It is about the size of a rabbit, brown in colour, and with hind legs less developed than in larger macropods. The potoroo inhabits scrubby areas where it has runways through the tussocky vegetation. It is fairly plentiful in parts of the Portland district, and it occurs also near Colac and about the Otway Ranges.

Whales and Dolphins (Order *Cetacea*)

The truly marine mammals have the front limbs modified into flippers and the hind limbs form horizontal flukes. Unless accidentally stranded, they do not come ashore at any time. About 30 species have been listed as occurring in Australian waters, but Victoria has definite records of only seven species.

Whalebone whales (family *Balaenopteridae*) are the species in which rudimentary teeth are replaced early by whalebone or baleen—the fringed plates which are used to strain minute crustaceans and other organisms from the sea water.

The Rorqual or Blue Whale (*Balaenoptera musculus*) is the largest of all animals. It may attain a length of over 100 feet. The species has a world-wide distribution, and a 90-ft. specimen was washed up on to the beach outside Port Phillip Bay in 1867.

The Humpback Whale (*Megaptera nodosa*) is fairly common in the Australian seas, and specimens are occasionally stranded on the Victorian coast. It grows to about 50 feet in length.

Toothed whales (family *Delphinidae*) are armed with numerous teeth, for they are mainly carnivorous. The following four species frequent Victorian seas :—

The Killer Whale (*Orcinus orcus*) grows to 30 feet in length and has a large dorsal fin. Killers hunt in packs ; they eat seals and dolphins and will even attack and kill whales much larger than themselves.

Schools of Pilot Whales (*Globiocephalus melas*) are sometimes stranded and die on beaches of eastern Victoria. There have been two such occurrences during the past twenty years—one on the Ninety-mile Beach and the other near Port Welshpool. The reason for this is not certain, but it is probably linked with seasonal migration north along the east coast of Australia. A school which is off-course in Bass Strait may endeavour instinctively to move to the north. Pilot Whales grow to almost 30 feet in length and are black with a rounded head.

The common dolphin (*Delphinus delphis*) grows to several feet in length. Groups or schools of them are often seen in bays and other near-coastal waters of the State. The Bottle-nosed Dolphin (*Tursiops truncatus*) is larger and less common. It has a shorter " beak " and a longer lower jaw.

The final Victorian whale record is of a member of the family *Ziphiidae* : a Beaked Whale (*Mesoplodon layardi*) was stranded near Port Fairy in 1962. The species is blackish and grows to about 18 feet in length. It has a single large tooth which, in the male, projects tusk-like on either side of the lower jaw.

Seals (Order *Pinnipedia*)

These sea-going mammals have all four limbs adapted to form paddles or flippers. However, the claws of the feet are present, and the limbs can be used to a certain extent for movement on land.

Eared seals (family *Otariidae*) have a small but definite ear auricle (*pinna*), and softly furred coat. The hind flippers are strong and can be turned forward to support the body for progress on shore. All the teeth are incisor-like, for cutting their fish food, large pieces of which are swallowed with no preliminary mastication.

Colonies of fur-seals (*Gypsophoca dorifera*) occur off the Victorian coast, on islands such as the Skerries in the east, Seal Rocks near Westernport Bay, and Lady Julia Percy Island off Port Fairy. They live in large groups, and usually each male or bull has a harem of several females. During the breeding season, fighting occurs between males, and they usually bear numerous scars from wounds inflicted by the sharp teeth.

On Lady Julia Percy Island small parties of a larger species, the Australian Sea-lion (*Neophoca cinerea*), are occasionally seen. The males are recognized by their conspicuous whitish manes. This is a South Australian species, very rare now in Victorian waters but reputedly plentiful originally in western Bass Strait.

Species of true seals (family *Phocidae*) occasionally visit Australian waters, but they are merely stragglers from Antarctic seas. In this group, the species have no soft fur, and they lack the ear pinna. They are more truly aquatic, for their hind limbs are directed

backwards and cannot be used as legs for progress on land. When out of water they wriggle along. The following three of this group are recorded for Victoria:—

The Leopard Seal (*Hydrurga leptonyx*) is large and spotted. It inhabits seas about Antarctica and the sub-Antarctic islands, feeding mainly on penguins. Occasionally, one visits Victorian waters, and there is a record of a Leopard Seal entering the mouth of the Snowy River and making its way upstream to the vicinity of Orbost in 1926.

The Crab-eater Seal (*Lobodon carcinophaga*) is an even rarer visitor from Antarctica. It is a large, light-coloured species with a small head; and its remarkably lobed molar teeth are used to strain water from the small crustaceans which constitute its food. A few years ago a Crab-eater Seal appeared for a short time in Port Phillip Bay.

Elephant Seals (*Mirounga leonina*) are massive, males growing to a length of 20 feet and weighing about 3 tons. They apparently lived about Tasmania and Bass Strait islands originally, but now only rarely does one appear in Australian waters. It is reported that a solitary Elephant Seal has visited Lady Julia Percy Island a few times during recent years, and one was stranded on a beach near Port Fairy.

Rats and Mice (Family *Muridae*)

These rodents are characterized by the upper and lower jaws, each having two chisel-like incisors which protrude forward, while the only other teeth are the molars set well back in the mouth.

Water-rats comprise a separate sub-family. They inhabit streams, lakes, swamps, and inlets, and feed mainly upon small aquatic animal life. Their nests are built in hollow logs or in piles of debris in or near the water. The combined length of head and body is as much as 12 inches, and the apical part of the tail is white.

The Eastern Water-rat (*Hydromys chrysogaster*) is usually golden-brown in colour, and it is abundant in most districts of Victoria. All other native Victorian rodents belong to the very large sub-family which contains also the introduced rats and mice.

The true rats (genus *Rattus*) are represented in the State by three native species. They live in extensive warrens from which definite runways radiate, and at night they range widely in search of food. Like the introduced species, the native ones are omnivorous.

The Allied Rat (*Rattus assimilis*) is greyish-brown, with a long tail and pale feet. It is very abundant in central Victoria and Gippsland, where its habitats include wet fern gullies, coastal heathlands, and the snow-gum woodlands of the sub-alps.

Mammals of Victoria

The Echidna (Tachyglossus aculeatus)

Egg-laying Mammals (Monotremata)

The Platypus (Ornithorhynchus anatinus)

[Photos: Aust. News and Publicity Bureau]

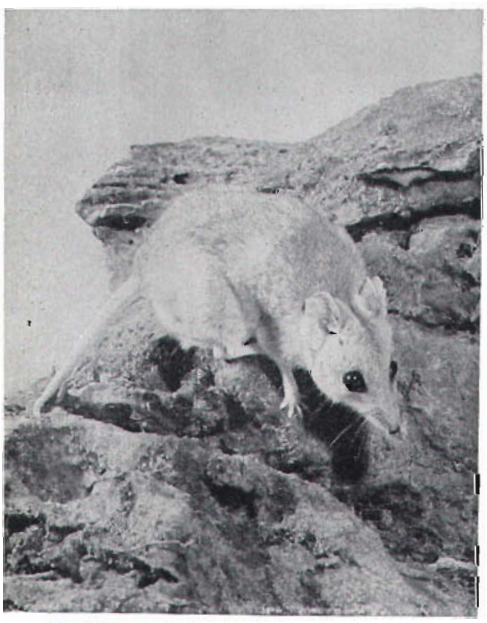
Family Dasyuridae

The Quoll
(Dasyurus quoll)

Brown
Phascogale
With Young
(Antechinus
stuartii)

[*Photos:*
N. A. Wakefield]

The Tuan (Phascogale tapoatafa)



Fat-tailed Dunnart
(Sminthopsis crassicaudata)
[*Photo: C O. Kroker*]

Possum Family (Phalangeridae)

The Mundarda (Cercartetus concinnus)

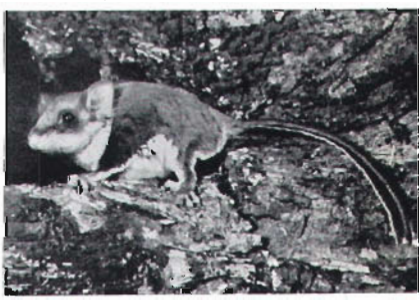
[*Photos: N. A. Wakefield*]

Sugar Glider (Petaurus breviceps)

Squirrel Glider (Petaurus norfolcensis)

The Feathertail (Acrobates pygmaeus)

[*Photo: N. A. Wakefield*]



Dusky Glider (Schoinobates volans)

[*Photo: David Fleay*]

Marsupials :

Kangaroo
Family
(Macropodidae)

Brush-tailed
Rock-wallaby
(Petrogale penicillata)
[Photo: N. A. Wakefield]

Mob of Grey Kangaroos (Macropus major)

[Photos: Aust. News and Publicity Bureau]

Female Grey Kangaroo and Joey

(Marsupialia)

The Koala (Phascolarctos cinereus, family Phalangeridae)

Barred Bandicoot (Perameles gunnii, family Peramelidae)

[*Photos. Fisheries and Wildlife Dept.*]

The Wombat (Phascolomis mitchellii, family Phascolomidae)

Marsupials :

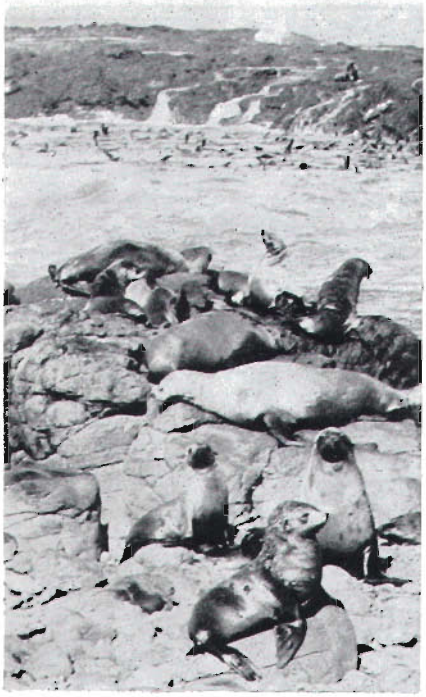
The Ringtail
(Pseudocheirus peregrinus)

The Silver-grey
(Trichosurus
vulpecula)

[*Photos: N. A. Wakefield*]

Leadbeater's Possum
(Gymnobelideus leadbeateri)

Placental Mammals (Monodelphia)



[*Photo: Fisheries and Wildlife Dept.*]
Fur Seal (Gypsophoca dorifera)

The Dingo (Canis antarcticus)
[*Photo: Aust. News and Publicity Bureau*]

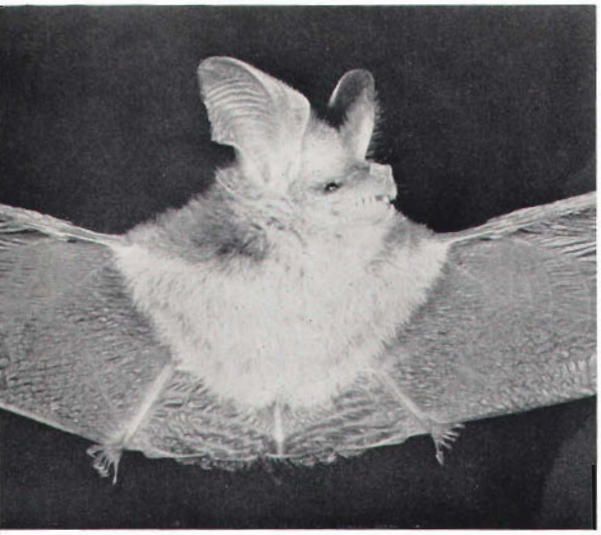
Swamp Rat (Rattus lutreolus)
[*Photo: N. A. Wakefield*]

[*Photo: E. R. Rotheram*]
Allied Rat (Rattus assimilis)

Leopard Seal (Hydrurga leptonyx)
[*ANARE photo by W. R. J. Dingle*]

Placental Mammals

Small Bats (Order Chiroptera)

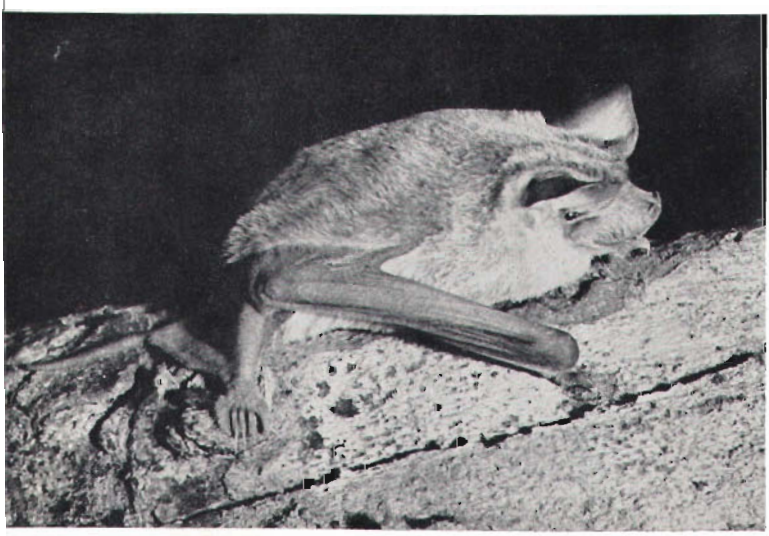


Long-eared Bat (Nyctophilus geoffroyi)

Horseshoe Bat (Rhinolophus megaphyllus)

Gould's Bat (Chalinolobus gouldii)

Little Brown Bat (Eptesicus pumilus)



Mastiff Bat (Tadarida planiceps)

[*Photos: N. A. Wakefield*]

Grey's Rat (*Rattus greyii*) is a South Australian species, extending in fair abundance into the Portland district of Victoria. It resembles the Allied Rat in most features but is smaller in size and has minor differences in skull structure. That these two are distinct species is a matter of doubt.

Swamp-rats favour wet terrain, usually with a dense coverage of sedges, grass, and rushes ; and their runways are particularly well defined. The general colour of body and feet is a rich brown, and the tail is rather short. The Victorian species, the Eastern Swamp-rat (*Rattus lutreolus*), is plentiful in near-coastal areas and it extends inland to north-western Gippsland and across the Western District to the Grampians.

Little is known of the remnant in Victoria of the once abundant *Pseudomys* group. Two species, and perhaps a third, still survive, but each has been recorded in this State only once or twice during the present century. Species of *Pseudomys* and its allied genera are very different from true rats in details of skull and teeth, but they are very similar in outward appearance. However, females of the genus *Rattus* have six or more nipples, including always one very close to each fore-limb, while in species of the *Pseudomys* group there are four only—all on the abdomen.

The Broad-toothed Rat (*Mastacomys fuscus*) was found in the Otway Ranges some 30 years ago, and recently it was rediscovered in Gippsland. In size and colour it is practically identical with the Swamp-rat, but it has extremely broad molar teeth as well as characteristic cranial features.

There is but one record of living specimens of the Smoky Mouse (*Gyomys fumeus*) : its original discovery, in the Otway Ranges about 30 years ago. It is light-grey in colour and smaller in size than the native rats.

The fourth type of native rodent represented in Victoria is the hopping-mouse (genus *Notomys*), which jumps along on the hind feet like a miniature kangaroo. The local species is Mitchell's Hopping-mouse (*Notomys mitchellii*). It inhabits semi-desert areas of the north-west of the State, making deep burrows in the sand. The species was rediscovered near Nhill, in 1955, after a period of 37 years without trace of it in Victoria.

Bats (Order *Chiroptera*)

Mammals of a number of different orders have the ability to glide through the air, but bats are the only ones that have the power of true flight. A bat's wings are formed mainly by the great elongation of four digits of each fore-limb. From the tips of the " fingers " stretches a thin membrane to the hind-limb and thence to the tail. All five digits of the hind-limb, as well as the first one of the fore-limb, are free, and each is terminated by a hooked claw. These claws enable a bat to climb about, and its normal sleeping position is hanging upside-down by the claws of the feet.

Because of similarity in colour and in the appearance of the head, fruit-bats (family *Pteropodidae*) are often referred to as " flying foxes ". They may have a wing-span of 4 ft., though the body weight rarely exceeds 2 lb. They roost in large rookeries during the day, usually high in trees, and at night move off in quest of food. Fruit-bats have normal eyesight, and they feed mainly on native and cultivated fruit.

Though the group is typically tropical, there is usually an intrusion of the Grey-headed Fruit-bat (*Pteropus poliocephalus*) into eastern Victoria each year. In summer and early autumn, they attack apples growing in the Cann River–Mallacoota district. Often they come to the Orbost area, sometimes as far west as Bairnsdale, and on rare occasions fruit-bats visit Melbourne. Their activities in apple orchards are quite drastic for, as they scramble about, they knock large quantities of fruit from the trees. There are a few records of fruit-bats—apparently lone stragglers—from northern and western Victoria.

The second, and by far the larger, group of bats are insect-eaters, and on the average their wing-span is about 1 ft. They do not possess normal eyesight, but have the equivalent in a well-developed sound-echoing system. A series of high-pitched sounds are emitted vocally and, when these rebound from solid objects, echoes are registered by an auditory nerve system and relayed to the brain. This enables a picture to be obtained in much the same way as other animals see with their eyes. An advantage of the small bats' " sight " is that it functions normally in complete darkness.

During the day, small bats hide away in a variety of places, and each kind seems to have definite preferences in the choice of a home. Nine Victorian species are forest bats, and three inhabit caves. The natural habit of forest bats is to hide in the hollow limbs and trunks of trees or behind loose sheets of bark. However, many of them have learned to live in our buildings, and they may take up residence in the roofs of houses, in church towers, or amongst material stored in sheds.

The following eleven species are Victoria's small bats:—

Horseshoe-bats (family *Rhinolophidae*) have a facial outgrowth known as a nose-leaf, the front part of which is shaped like a horseshoe. The Eastern Horseshoe-bat (*Rhinolophus megaphyllus*) is the sole Victorian species of the family. It is fairly plentiful in a few of the large limestone caves of the Buchan district in Gippsland, but it apparently does not live elsewhere in the State. It always roosts singly, with the wings folded about the body.

Simple-nosed Bats (family *Vespertilionidae*) have little or no development of the nose-leaf, and there are at least the following seven species of the family in Victoria.

The long-eared bats, as their name implies, are characterized by very large ears which, however, are folded up while they are sleeping. There are two local species. The Lesser Long-eared Bat (*Nyctophilus geoffroyi*) is the more plentiful and it is the small bat which habitually

comes into country houses at night. It is recognized by a conspicuous grooved ridge on the nose. The Greater Long-eared Bat (*Nyctophilus timoriensis*) is less known, though apparently it is not rare in Victoria.

The Little Brown Bat (*Eptesicus pumilus*) is a tiny animal with very short rounded ears. It, too, is a forest bat of wide distribution.

Members of the genus *Chalinolobus* have wattle-like lobes between mouth and ear, so they are sometimes referred to as wattled bats. There are two species in Victoria: the Chocolate Bat (*Chalinolobus morio*) and Gould's Bat (*Chalinolobus gouldii*). The former is quite small and is best recognized by the pointed inner ear-lobe (*tragus*), while the latter is larger and has a rounded *tragus*. Of the two, Gould's Bat is the commoner, and though, like the other, it is a forest species, it has been known to inhabit buildings.

The Large-footed Myotis (*Myotis macropus*) has the ears narrow and somewhat pointed, and the *tragus* is very slender. A small colony lives in a cave near Buchan, but it is a very uncommon species in south-eastern Australia.

The common cave bat in the State is the Bent-wing (*Miniopterus schreibersi*), a medium-sized brown species with short nose, abruptly elevated cranium and short rounded ears. It inhabits caves in basalt and limestone country as well as deep crevices in granite and other rock outcrops. Some caves house many thousands of bent-wings, and there may be over a thousand in one tightly packed cluster clinging to a cavern roof. Members of the two preceding families of bats have the whole tail incorporated within the flying membrane, whereas those of the following two families have the apical half of the tail projecting beyond the membrane.

The sole representative of the free-tail bats (family *Emballonuridae*) in Victoria is the Yellow-bellied Bat (*Saccolaimus flaviventris*), a comparatively large species with pointed nose, dark back, and yellowish underparts.

Mastiff-bats (family *Molossidae*) are distinguished from other local groups by the pug-like face, with short muzzle and wrinkled lips, and the forward-projecting bonnet-like ears. They are sometimes referred to as " scurrying bats ", because they scramble about on the ground or trunks and limbs of trees, in search of insects. There are two Victorian mastiff-bats. The White-striped Bat (*Tadarida australis*) is Victoria's largest insectivorous species, having a wing span of about 17 inches. Along each side, beneath the wing, is a broad stripe of white hair. The species is widespread in Victoria. The Little Mastiff-bat (*Tadarida planiceps*) is small and grey, and it appears to be restricted in Victoria to north-western districts.

The Dingo

Although its ancestors were originally brought to this country by man, the dingo has been resident long enough to be included with the native fauna of Australia. Even though it interbreeds with strains of the domestic dog, zoologists usually regard it as a separate species and it may therefore be distinguished as *Canis antarcticus*.

Dingoes have a broad head and fairly short pricked ears, and the tail is rather bushy. The usual colour is dark yellow, often merging to blackish at the points. However, blackish and brindled specimens were noted by early explorers. Dingoes do not bark, but their mournful howling is a feature of some remote areas, and they also have yapping calls.

Wallabies are the dingo's natural food, but many have become sheep-killers. Consequently, they have been classified as vermin; trappers are employed to keep their numbers down; and a bounty is paid for their destruction. In spite of these hazards, they still frequent unsettled areas, particularly along stretches of the coast and in the mountains.

Introduced Mammals

Since the European occupation of Australia, Victoria has acquired fourteen species of exotic mammals which now have permanent breeding populations outside the control of man.

Rabbits and Hares

The rabbit (*Oryctolagus cuniculus*) is widespread and abundant. It presents a major economic problem, necessitating the construction of wire-netting fences around pastures. It is legally classified as "vermin" and landholders are obliged to endeavour to eradicate rabbits from their properties.

A great number of species of native plants are prevented from regenerating normally, because rabbits eat off their seedlings. This has altered the composition of the natural vegetation of the country, reducing herbaceous ground cover and inducing the growth of scrub. As a result, there is an increase in the immediate run-off of rain-water. Soil erosion has occurred, coupled with the silting-up of streams. In particular, the water-holding capacity of the soil has been reduced, and many streams which were once permanent now cease to flow during prolonged dry periods. This has had drastic and far-reaching effects on catchment for town and city water supplies and for irrigation. The recent introduction of myxomatosis has reduced the rabbit population in many areas, but it appears that the survivors have acquired immunity from the disease.

The Hare (*Lepus europaeus*) is fairly plentiful in open grasslands and savannah forests in many parts of Victoria, but unlike the rabbit it has not become a serious pest.

Squirrels

Of the oversea rodents, the Eastern Grey Squirrel (*Sciurus carolinensis*) has been introduced to the Melbourne area and is now well established in eastern and south-eastern suburbs. Some were taken to Ballarat, too, and a population of them inhabits a section of public parks and private gardens near Lake Wendouree.

European Rats and Mice

These were introduced to Australia very early. The domestic mouse (*Mus musculans*) lives about buildings and in fields, and it is well established even in remote parts of the countryside, especially in western Victoria. Both the black and the grey varieties of the Ship Rat (*Rattus rattus*) are abundant in settled places, and one or the other is often found in areas of native vegetation. The Brown Rat (*Rattus norvegicus*) remains more closely associated with human habitation, living beneath buildings and frequenting drains in built-up areas.

Foxes

The European fox (*Vulpes vulpes*) has become established in practically every corner of the Victorian countryside, from the coast to the Murray River and from the Mallee to the eastern highlands. Its attacks on poultry and its habit of killing young lambs are well known. Where rabbits occur, it preys on them, and foxes consume numbers of insects such as beetles and grasshoppers. The most significant activity of the fox, however, is the destruction of native fauna, particularly of ground-frequenting birds. Its effect on small members of the kangaroo family has already been discussed.

Cats

The domestic cat (*Felis catus*) has become uncontrolled not only about settlement but in remote parts of the bush. Usually, after a few generations, feral cats revert to tortoise-shell colouration. They live on rabbits in many areas, but where these are not available, their prey consists of small native mammals and birds.

Tame domestic cats tend to eliminate small insectivorous birds from the vicinity of the houses to which they belong, and in country areas they often hunt at night and kill phascogales, gliders, and other native mammals.

Horses

The brumby or wild horse (*Equus caballus*) inhabits the rugged mountain country of eastern Victoria. There are usually family groups comprising a stallion, a few mares, and a number of foals. Individuals may be black, white, brown, grey, or roan.

There are many thousands of brumbies in the Australian Alps. They range over the highest mountain tops during the summer and, in winter, come down to the valleys to escape the snows. They have descended from animals that escaped in the early days of settlement.

Deer

Several kinds of deer (family *Cervidae*) have been introduced into Australia and three species are well established in Victoria. Largest of them is the Indian sambur (*Cervus unicolor*), which is fairly plentiful in the heavily forested areas east and north-east of Melbourne, from Gembrook to the Baw Baws and beyond Marysville. Stags

average 450 to 500 pounds in weight and, after their second year, grow antlers with six points, three on each. Does are much smaller. The Scottish Red Deer (*Cervus elaphus*) inhabits the Otway Ranges, Grampians, and Mount Cole forest, in western Victoria. A full-grown stag may have antlers with as many as eighteen points. Red Deer favour more open forest country than do sambur. On Wilson's Promontory and other parts of south Gippsland, the Japanese Hog Deer (*Cervus porcinus*) may be found. It is a brown animal with light spots and, though the males have fine antlers, an individual stands no more than thirty inches high.

Fallow Deer (*Cervus dama*) are reported to have occurred in the Marysville district, too, but whether any still survive there is uncertain.

Goats

Wild goats (*Capra hircus*) roam at large in widely separated parts of Victoria. Some occur about the Lerderderg Gorge, west of Melbourne, others in the Mallee, and further groups in east-central districts of the State. A herd of wild goats may number several beasts, but in some cases there are as many as forty. They frequent rocky terrain by preference, and there is usually a lookout posted to warn others of approaching danger.

*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,

* Excluding rivers and water resources, which are described in detail on pages 30 to 43.

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 27·88 per cent. of the Australian population at 30th June, 1961. In relating population to area, Victoria is the most densely populated of the States with an average density at 30th June, 1961, of 33·34 persons per square mile and is exceeded only by the Australian Capital Territory (62·65 per square mile).

The Victorian population is growing rapidly; comparing the enumerated population of the Census of 30th June, 1954, with that of 30th June, 1961, the population of Victoria increased by 19·48 per cent., being exceeded by South Australia (21·61 per cent.), the Australian Capital Territory (94·06 per cent.), and the Northern Territory (64·52 per cent.).

The distribution of population over the State, however, is very uneven. At the 1961 Census no less than 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).

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 (population at 30th June, 1961, 91,777), Ballarat (54,880) and Bendigo (40,327), 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), Wangaratta (a rather special case of decentralized industries), Shepparton (fruit canneries), and Mildura (fruit and

vegetable packing). Next, there are a number of regional urban centres 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
Australia (Total)	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 Surveys, 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 References

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 Bay was the first place where settlement was made, at Sorrento in 1803, by a party under Lieutenant-Colonel Collins. In January, 1804, the settlement was abandoned.

Wilson's Promontory is the most southerly part of the State of Victoria; it was rounded by Lieutenant Grant in the *Lady Nelson* in 1801. The original entrance to Lakes Entrance was, owing to silting, closed in 1889, and a new entrance opened 1½ miles to the west.

When Lieutenant Grant called at an island in Western Port in 1801, he named it Churchill Island (after an English Government official, who supplied a small amount of seed). Wheat was planted

and when Lieutenant Murray in the *Lady Nelson* visited the island some months later, the wheat was growing vigorously, being 6 feet high. It was the first wheat planted in Victoria.

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.
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 and Water Resources

Hydrology Characteristics

Length

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

(1) The length, and

(2) the catchment.

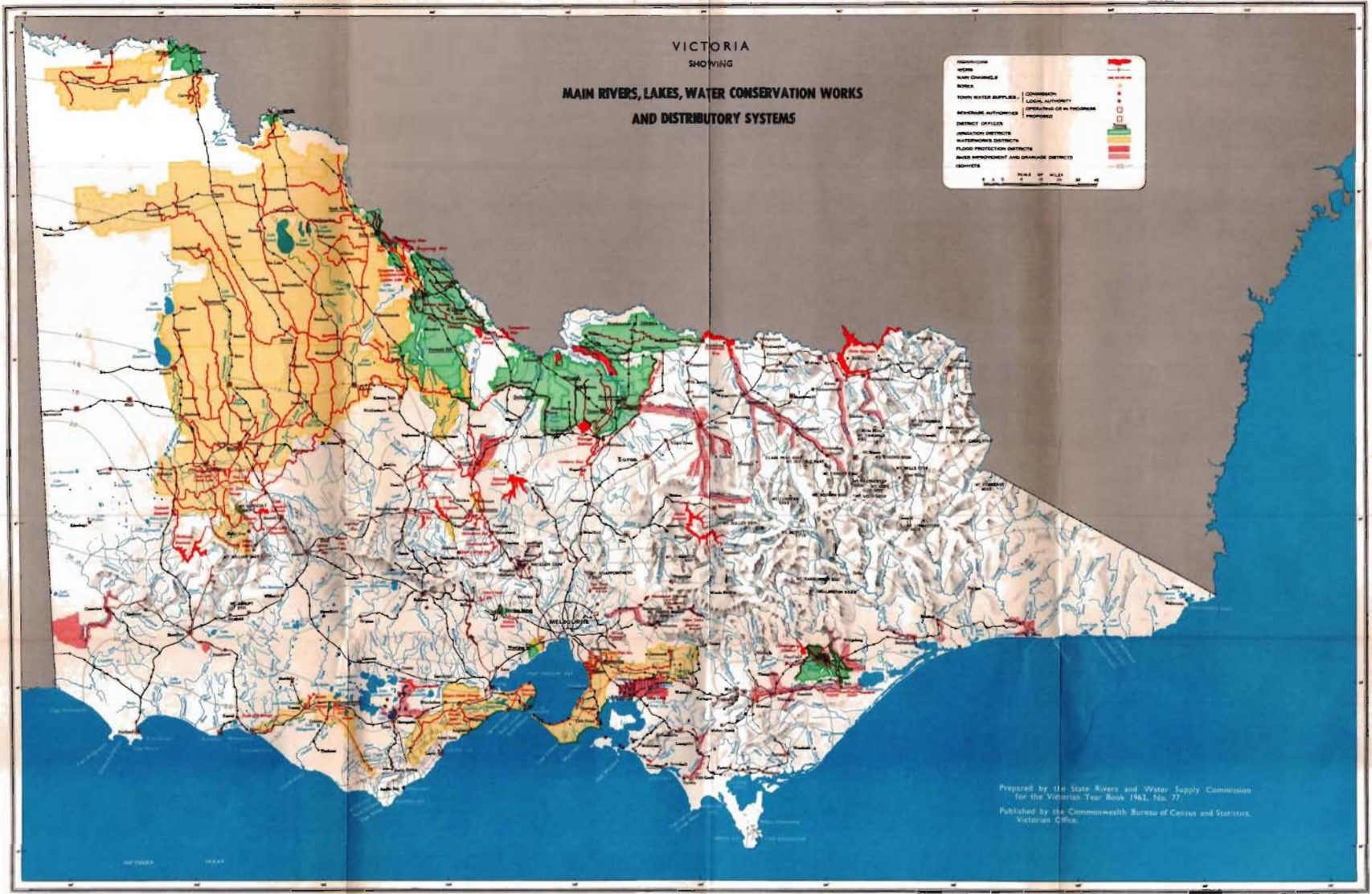
The following table shows the main river basins of Victoria and flows of the main streams :—

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.


VICTORIA
SHOWING
MAIN RIVERS, LAKES, WATER CONSERVATION WORKS
AND DISTRIBUTORY SYSTEMS
TOWN WATER SUPPLIES
COMMISSION
LOCAL AUTHORITY
IRRIGATION AUTHORITIES
OPERATING OR IN PROGRESS
PROPOSED
DISTRICT OFFICES
IRRIGATION DISTRICTS
WATERWORKS DISTRICTS
FLOOD PROTECTION DISTRICTS
RIVER IMPROVEMENT AND DRAINAGE DISTRICTS
ISOHYETS
SCALE OF MILES
MELBOURNE
Prepared by the State Rivers and Water Supply Commission
for the Victorian Year Book 1962, No. 77.
Published by the Commonwealth Bureau of Census and Statistics,
Victorian Office.

The latest figures for the lengths of Victoria's rivers are shown in the following table :—

VICTORIA—LENGTHS OF STREAMS AND RIVERS

Stream	Approximate Length	Main Stream Basin
	miles	
Aberfeldy River	43	Thomson
Acheron River	35	Goulburn
Agnes River	23	South Gippsland
Aire River	25	Otway
Albert River	25	South Gippsland
Avoca River	168	Avoca
Avon River	75	Wimmera
Avon River	76	Thomson
Axe Creek	30	Campaspe
Back Creek	20	Portland
Back (or Boosey) Creek	45	Broken
Barkly River, East West and Mt. Skene Branches	24	Thomson
Barr Creek	20	Loddon
Barwon River	117	Barwon
Bass River	37	South Gippsland
Bemm River	60	East Gippsland
Benambra Creek	45	Mitta Mitta
Bendigo Creek	99	Loddon
Bet Bet (or McNeils) Creek	58	Loddon
Big River	32	Goulburn
Birregurra Creek	20	Barwon
Black River	24	Goulburn
Bobby Dick Creek	12	Ovens
Boggy (or Prospect) Creek	37	Mitchell
Bolinda (or Emu) Creek	31	Maribyrnong
Bradford Creek	24	Loddon
Brankeet Creek	30	Goulburn
Bream Creek	28	Otway
Brodribb River	70	Snowy
Broken Creek	20	Hopkins
Broken Creek	140	Broken
Broken River	120	Goulburn
Bruthen Creek	30	South Gippsland
Buchan River	75	Snowy
Buckland River	30	Ovens
Buffalo River	55	Ovens
Bulabul Creek	24	Loddon
Bullarook (or Birches) Creek	30	Loddon
Bullock Creek	110	Loddon
Bundarrah Creek	25	Mitta
Bunyip River	39	Bunyip
Burnt Creek	25	Wimmera
Burrumbeet (or Bo Beep) Creek	23	Hopkins
Cabbage Tree Creek	27	Snowy
Campaspe River	153	Campaspe
Cann River	62	East Gippsland
Cardinia Creek	27	Bunyip
Castle Creek	40	Goulburn
Cherry Tree Creek	20	Avoca
Chetwynd River	25	Glenelg
Cobungra Creek or River	26	Mitta
Cochrans Creek	20	Avoca

VICTORIA—LENGTHS OF STREAMS AND RIVERS—*continued*

Stream	Approximate Length	Main Stream Basin
	miles	
Coimadai (or Pyrote) Creek ..	24	Werribee
Coliban River	60	Campaspe
Concongella Creek	25	Wimmera
Cornella Creek	40	Campaspe
Corryong (or Jeremal Nariel, Wheelers or Zulu) Creek	55	Upper Murray
Crawford (or Smoky) River ..	45	Glenelg
Creightons Creek	25	Goulburn
Cudgee (or Brucknells) Creek ..	20	Hopkins
Cudgewa Creek	46	Upper Murray
Curdies River	54	Otway
Dabyminga Creek	27	Goulburn
Dandenong Creek (including Patterson River)	34	Bunyip
Dargo River	58	Mitchell
Darlots Creek	20	Portland
Dart River	20	Mitta
Deddick (or Jingella) River ..	37	Snowy
Deegay Ponds or Majors Creek ..	30	Goulburn
Delatite River	58	Goulburn
Delegate River	66	Snowy
Diamond (or Arthurs or Back) Creek	24	Yarra
Diddah Diddah Creek	16	Ovens
Doma Mungi (or Black Dog) Creek	40	Ovens
Drysdale Creek	20	Hopkins
Dunmunkle Creek	57	Wimmera
Dwyers Main Creek	25	Glenelg
Eaglehawk Creek	17	Latrobe
Emu Creek	33	Maribyrnong
Errinundra River	20	East Gippsland
Eumeralla River	80	Portland
Ferrers Creek	23	Corangamite
Fiery Creek	73	Hopkins
Fifteen Mile (or Three Mile) Creek ..	47	Ovens
Fitzroy River	26	Portland
Flinn's (or Flynns) Creek	20	Latrobe
Fords Creek	20	Goulburn
Franklin River	25	South Gippsland
Freestone Creek	30	Wimmera
Fyans Creek	20	Wimmera
Gellibrand River	75	Otway
Genoa River	60	East Gippsland
Glenelg River	284	Glenelg
Glenmaggie Creek	25	Thomson
Gnarkeet Chain	24	Corangamite
Goulburn River	352	Goulburn
Grange Burn	26	Glenelg
Gunbower Creek	80	Loddon
Happy Valley Creek	20	Ovens
Hodgsons Creek	20	Ovens
Hollands Creek	40	Broken
Hopkins River	170	Hopkins
Howqua River	47	Goulburn
Hughes Creek	45	Goulburn
Hentys (or Miakite or Grassdale) Creek	23	Glenelg

VICTORIA—LENGTHS OF STREAMS AND RIVERS—*continued*

Stream	Approximate Length	Main Stream Basin
	miles	
Indigo Creek	23	Ovens
Jackson's (or Macedon) River ..	55	Maribyrnong
Jamieson Creek	42	Otway
Jim Crow (or Sailors) Creek ..	29	Loddon
Jinallala (or Deddick) River ..	37	Snowy
Joyces (or Glengower) Creek ..	32	Loddon
Kiewa (or Little) River	115	Kiewa
King Parrot (or Harrangearnong) Creek	30	Goulburn
King River	92	Ovens
Koetong (or Cooyatong or Running) Creek	23	Upper Murray
Koonongwootong (or Koroite or Bryants) Creek	25	Glenelg
Koroite (or Bryants) Creek ..	36	Glenelg
Kororoit Creek	43	Werribee
Lang Lang River	34	Bunyip
Latrobe River	156	Latrobe
Leigh (or Yarrowee) River	80	Barwon
Lerderderg River	41	Werribee
Lindsay River	30	Mallee
Little River	40	Moorarbool
Little Woady Yaloak River or Creek (or Moonlight Creek)	20	Corangamite
Livingstone Creek	32	Mitta
Loddon River	237	Loddon
Macalister River	108	Thomson
Maribyrnong River	114	Maribyrnong
Marraboor (or Little Murray) River ..	35	Upper Murray
Mathers Creek	20	Glenelg
Merri River	44	Hopkins
Merri Creek	45	Yarra
Merriman's Creek	60	South Gippsland
Middle (or Captains) Creek ..	28	Loddon
Mitchell River	156	Mitchell
Mitta Mitta River (incl. Big River) ..	178	Mitta
Mooneeponds Creek	20	Yarra
Moorarbool River	95	Moorarbool
Morka River	25	Mitchell
Morwell River	30	Latrobe
Mountains Creek	25	Snowy
Moyne River	40	Portland
Mt. Cole Creek	18	Wimmera
Mt. Emu Creek	165	Hopkins
Mt. Greenock (or McCallums) Creek	30	Loddon
Mt. Hope (or Piccaninny or Bendigo) Creek	120	Loddon
Mt. Pleasant Creek	23	Campaspe
Mt. William (or Mokepilly) Creek ..	63	Wimmera
Muckleford Creek	20	Loddon
Muddy Creek	35	Goulburn
Murrabit River	35	Loddon

VICTORIA—LENGTHS OF STREAMS AND RIVERS—*continued*

Stream	Approximate Length	Main Stream Basin
	miles	
Murraboor (or Little Murray) River ..	35	Loddon
Murray River	Total 1,600 miles, incl. 1,200 miles from S.A. and Vic. Border to source at Forrest Hill	Murray
Murrindal River	35	Snowy
Murrindindi Creek	20	Goulburn
Mustons Creek	50	Hopkins
Myers Creek	32	Loddon
Myrtle Creek	20	Campaspe
McKenzie River	36	Wimmera
Naringhil Creek	29	Corangamite
Native Hut Creek	25	Barwon
Nicholson River	50	Tambo
Nortons Creek	29	Wimmera
Outlet Creek	80	Wimmera
Ovens River	142	Ovens
Perry River	35	Wimmera
Plenty River	42	Yarra
Powlett River	21	South Gippsland
Pyramid Creek	140	Loddon
Reddy (or Reids or Eldorado) Creek	44	Ovens
Richardson (or Rich-avon) River ..	35	Wimmera
Rose River	30	Ovens
Ryans (or Kelferra or Kilfers) Creek	30	Broken
Salt Creek	35	Hopkins
Serpentine Creek	35	Loddon
Sevens Creek	60	Goulburn
Shaw River	32	Portland
Skeleton Water Holes Creek ..	24	Werribee
Snowy Creek	26	Mitta
Snowy River	Total 270 miles, 110 miles incl. in Victoria	Snowy
Spring Creek	30	Hopkins
Stokes River (or Emu Creek) ..	30	Glenelg
Sugarloaf (or Mollisons) Creek ..	30	Goulburn
Sunday (or Running) Creek ..	32	Goulburn
Surrey (or Surry) River	23	Portland
Sutherlands Creek	20	Moorarbool
Tallangatta Creek	34	Mitta
Tambo River	124	Tambo
Tanjil River	45	Latrobe
Tarago River	22	Bunyip
Tarra River	27	South Gippsland
Tarwin River	82	South Gippsland
Thomson River	130	Latrobe
Thougla (or Thowgla) Creek ..	24	Upper Murray

VICTORIA—LENGTHS OF STREAMS AND RIVERS—*continued*

Stream	Approximate Length	Main Stream Basin
	miles	
Thurra River	55	East Gippsland
Timbarra River	36	Tambo
Toms Creek	20	Mitchell
Toomuc Creek	19	Bunyip
Toonginbooka River	28	Snowy
Trawalla Creek	20	Hopkins
Tsheea Creek	25	Broken
Tullaroop (or Deep) Creek	67	Loddon
Tyers River, also Eastern, Western and Middle Branches	30	Latrobe
Tyrell Creek	95	Avoca
Valencia Creek	25	Wimmera
Victoria River	30	Mitta
Violet Ponds (or Honeysuckle) Creek	35	Goulburn
Wabba Creek	25	Upper Murray
Wallpoola Creek	30	Mallee
Wando River	25	Glenelg
Wannon River	146	Glenelg
Warrambine Creek	36	Barwon
Watts River	23	Yarra
Wellington River	21	Thomson
Wentworth River	40	Mitchell
Werribee River	77	Werribee
Western Moorarbool River	33	Moorarbool
Whorouly Creek	17	Ovens
Wimmera River	181	Wimmera
Wingan River	26	East Gippsland
Woady Yaloak (or Smythes) Creek	67	Corangamite
Wongungarra River	40	Mitchell
Wonnangatta River	75	Mitchell
Woori Yallock Creek	23	Yarra
Yackandandah Creek	25	Kiewa
Yarra River	153	Yarra
Yarriambiack Creek	80	Wimmera
Yarrowee (or Leigh) River	80	Barwon
Yea River	40	Goulburn

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.

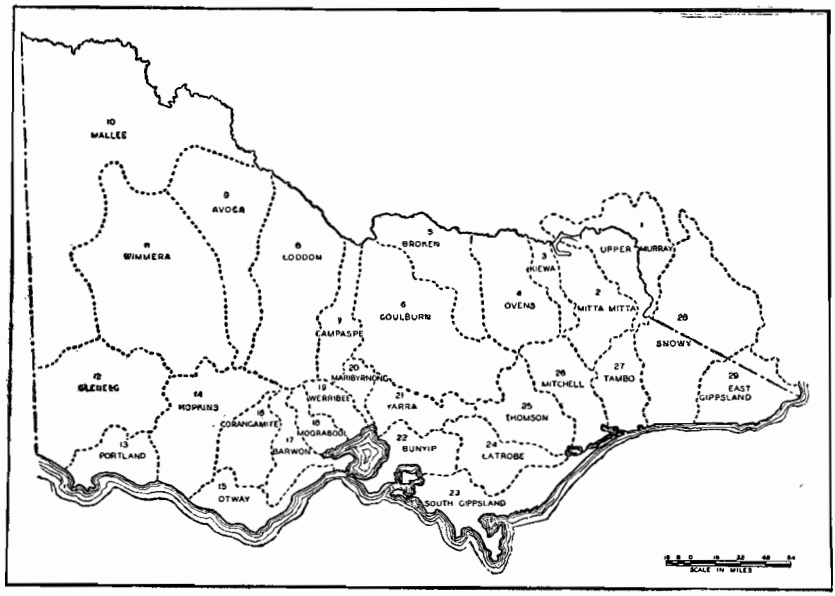


FIGURE 1.—Victoria's water resources showing key plan to river basins.

Stream Flow

Whereas the accuracy with which the length of streams and the area of catchments can be measured depends on the topographic detail of the maps available, sampling errors of stream flow decrease with increasing length of record. The " representativeness " of flows expressed as averages will depend to some extent on the actual years over which the flow is averaged. Hence, it is desirable to express such estimates of stream flow as " normals ", that is, averages taken over a particular period, usually not less than 30 years.

The " average " which is generally used is the simple arithmetic mean. A better average, which is in use in the United States of America, is the " median " or middle value which is such that the flow is greater than this value for half the time. The median is less than the mean for this case, sometimes by a considerable amount.

One obvious characteristic of stream flow is its variability and some measure of this is required. The maximum and minimum flows are often used, but as these values depend on the length of record this should be stated. For statistical purposes, values of the standard deviation or mean deviation are more suitable.

Flow Measurement

Apart from the inherent difficulty of giving firm values to stream flows because of the finite length of record, it is desirable to recognize that errors occur in the measurement of stream flows, more particularly

for extremes such as floods. Although methods of measurement may change in the near future, current practice largely follows that used for some years. Early flood estimates must therefore be used with caution.

Basically, the technique consists of determining the water level at a fixed point in the stream, preferably continuously, but often only once daily. By " gauging " the flow from time to time at different levels and noting the height at the time, a rating curve is built up over a period of years which enables the recorded levels to be converted to flows. Such flows are normally computed on a daily basis, but for publication are often shown as monthly values.

The major streams of Victoria are now gauged, records of some streams going back to the 1880's. These long records, where sufficiently reliable, give the basic information on flows (including floods and droughts) used in designing water supply schemes.

Although there are still hundreds of ungauged streams, their flows can often be inferred from correlation with gauged streams, but such correlation is greatly improved if some records are available. An assessment of the total flow in Victoria's streams can therefore be made.

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 with a view to including names which have appeared on them. There are, in addition, many un-named streams, those with locally known names, or names shown 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. Actually there are records of stages or river levels on the Murray at Echuca and near Mildura from 1865 obtained from staff gauges installed mainly for the benefit of river-boats. For this purpose the depth " above summer level " was all that was required, as this indicated the clearance above snags. Some of these stages have been used to estimate flood levels, and were particularly useful in determining the profile of the 1870 flood, the largest recorded on the Murray above the Darling. To compare this flood with the major flood of 1956, recorded heights must be adjusted when necessary so that they refer to the same gauge datum—a procedure that cannot always be carried out but, if overlooked, gives misleading results.

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.

For hydro-meteorological studies, rainfall data, which is collected by the Commonwealth Bureau of Meteorology, is required. By correlating rainfall and stream flow it is possible to estimate the run-off from the ungauged area of the State. Flow from the gauged streams averages about 14 million acre ft. per annum, the ungauged areas contributing about 3 million acre ft. per annum. Hence, although many streams are ungauged, their total flow is only about one-sixth of the flow of the gauged streams. Their flow characteristics can, if necessary, be estimated by correlation with gauged streams, or from rainfall data.

To compare stream flow with the rainfall from which it emanates, flow in acre ft. is converted to inches in depth over the State. This gives a mean run-off of 3½ ins. per annum from a mean rainfall of 25½ ins., the difference of about 22 ins. being the average annual loss by evapo-transpiration.

Floods

General

The natural history of unregulated rivers is largely the history of their floods and droughts. Rainfall intensity increases with decrease in latitude and consequently Victoria is less subject to floods than the northern States. The practical importance of floods is, however, largely related to the damage they do in occupied areas.

Flood damage usually occurs because of the occupation of flood plains and once occupied, there is a demand for protection which is commonly provided by levees. Such levees have been constructed along the major streams including the Murray, Snowy, and Goulburn, and also in urban areas occupying the flood plain of the Dandenong Creek. The objection to levees is that by restricting the flood plain, the flood level for a given discharge is increased, and if overtopping does occur, damage is more serious. Other flood mitigation measures used in Victoria such as straightening the stream to increase the gradient and flow rate have also been used on such streams as the Bunyip and the Yarra. Provision to prevent excessive scour may be necessary in some cases.

Creeping Floods

Another form of flood damage that has occurred in Victoria is associated with the so-called " creeping floods " where levels of lakes have risen so much above normal as to flood the marginal lands. This is due to a series of wet years upsetting the normal balance between evaporation and inflow. During the last decade, the winter rainfall in the region of Lake Corangamite was 15 per cent. above average, so that the level of the lake rose over 11 feet, increasing its area by about 20 per cent., and inundating about 20 square miles of marginal lands. Some reduction of the area flooded has been achieved by diverting the flow of the Woady Yaloak—the main stream feeding the Lake—to the Barwon. The water of the Woady Yaloak becomes saline when it mixes with the water in the Cundare Pool, the northern arm of Lake Corangamite, and the salinity of the water diverted is a factor limiting the diversion rate. A return to more normal climatic conditions will be the main factor in the Lake reverting to normal levels. Fortunately, it was possible to prevent excessive rise in Lake Colac, a smaller and less saline lake, by diversion to the Barwon.

Other Floods

Owing to the tendency for major floods to overflow the banks and, in flat country, to pass down other channels which may not rejoin the main stream, it is often difficult to determine even 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.

The year 1870 is regarded as the wettest that Victoria has experienced for over a century. As there were only thirteen rainfall stations whose records are available, the estimated average of 38 ins. over the State is crude, but is 3 ins. more than the next highest figure of 35 ins. in 1956. River gauges in 1870 were practically restricted to the Murray, and consequently flood estimates on other streams are crude and can only be inferred from dubious evidence. Furthermore, subsequent to the 1870 floods, levees were constructed along the Goulburn and other streams and consequently heights of subsequent floods were augmented by the restrictions imposed.

In the North-east, floods occurred in the years 1906, 1916, 1917, and 1956. Although records of flood flows at gauging stations on the main streams have been published, such estimates are open to correction in the light of more recent evidence. Owing in part to under-estimation of earlier floods, the protection at the S.E.C. works at Yallourn was inadequate and the 1934 flood overflowed the banks of the Latrobe into the open cut at Yallourn. This flood was caused by a storm which is, on the basis of rainfall over large areas, the most severe that has been recorded within Victoria. An earlier storm of December, 1893, which occurred over East Gippsland was heavier, but this also covered part of New South Wales.

Droughts

General

Although floods and flood damage are more spectacular than droughts and drought losses, the expenditure incurred in Victoria on flood mitigation is negligible by comparison with that on storages required to meet water needs in dry periods.

There is no universal definition of drought ; the British Meteorological Office definition of an " absolute drought " as a sequence of more than fifteen days without rain is obviously inapplicable to Australia. However, this definition indicates that drought involves a measure of duration. A similar measure of drought could be applied to streams which cease to flow, but for the more usual case of perennial streams, volumes of flow over a specified duration must be given.

Droughts in Victoria

Droughts to 1955 in terms of rainfall in Australia have been extensively analysed by the Commonwealth Bureau of Meteorology. There is no such extensive comparative analysis for stream flows, but analyses of Victorian streams to determine the worst ten consecutive years for major streams having up to 70 years of record, show that such flows may be less than half the mean value flow. For the best streams such as the Goulburn and Murray, the minimum ten year mean in 70 years is about 70 per cent. of the long-term average.

The two periods of ten years within the past 70 years that are driest commenced about 1895 and 1937. For shorter periods, 1914–15 and 1938–39 are about on a par, with 1943–45 the worst two consecutive years.

Storage for Droughts

Both the mean flow of a given stream and its variability will depend on where its flow is measured. Generally as the catchment increases the mean increases, but the variability decreases. However, for streams which flow into areas which do not contribute to the flow, the mean will tend to decrease, and the variability to increase. 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.

To provide water supplies during drought periods, storage is essential except for minor schemes. In the first stage of water resources development, " seasonal " storages, that is storages adequate to store winter flows for use in the following summer, were regarded as sufficient. However, winter flows may fail and output in the following summer will be curtailed unless the storage is large enough to " carry over " flows from previous years. There is, however, an economic limit to storage capacity and the idea of storing all water so that none runs to waste is wishful thinking. Even though there is no secular trend in climatic conditions, it is reasonable to assume that the magnitude of past droughts and floods will be exceeded in the future. Thus it is not possible to guarantee a particular output from storages, and for irrigation purposes at least, the economic output will be such that restrictions will be imposed in years of severe drought.

Water Use

Theory

As indicated in the previous section, hydrologic data are collected primarily to enable waterworks authorities to design and operate their schemes efficiently. In addition to stream flow data, topographic information is required to assess the suitability of storage sites—geologic data is required at dam sites, surveys are necessary for appurtenant works, such as channels and pipe lines—and soil surveys are needed in areas to be irrigated. The selection of the best storage sites involves too many technical factors to be given here. Schemes in which water is usefully employed may be for towns, irrigation, navigation, power ; or sometimes a combination of these uses. " Head ", which is vital in power projects, is relatively unimportant in town and irrigation schemes. Briefly, the economic analysis of a scheme involves the determination of costs and benefits. Costs may be determined by recognized methods, but the benefits often involve sociological factors more difficult to assess. For multi-purpose projects, the problem is even more complex if the water resources are to be used most efficiently, for this involves the *relative* benefits of, say, power and irrigation.

It is possible to estimate the uniform regulated output obtainable from a storage of given capacity if stream flow characteristics and permissible frequency of failure are known. In practice, other factors such as variation in demand with climatic conditions, restriction policy during droughts, evaporation losses, &c., render the problem even more complex, and quoted estimates of regulated output depend largely on the assumptions made in their computation. A considerable increase

in mean output is possible by applying restrictions in drought years. However, without a knowledge of the economic and other effects on such restrictions, the determination of optimum output can scarcely be regarded as an objective procedure as yet.

Town Supplies

There is no comprehensive publication dealing with the history of water use in Victoria, but the major authorities concerned, such as the State Rivers and Water Supply Commission, Melbourne and Metropolitan Board of Works, State Electricity Commission, &c., have in various publications and reports given surveys of their undertakings.

The increased population due to the gold mining activity in the early 1850's created a demand for water which resulted in the construction of schemes to the main towns of Melbourne, Ballarat, Bendigo, and Geelong. Melbourne originally drew its supply from the Yarra, but a purer source was sought when the Yarra became too polluted from industrial development and urban drainage. To obtain the necessary catchment area within a reasonable distance of Melbourne and with sufficient head for a gravity supply, the headwaters of the Plenty River, a tributary of the Yarra, were deemed suitable and the Yan Yean scheme was opened at the end of 1857. It was just a century later that the main stream was dammed to give a major storage on the Upper Yarra. The supply to Melbourne is still obtained practically exclusively from the water resources of the Yarra catchment, but adjacent catchments have not been overlooked.

It is fortunate that Ballarat is in an area where rainfall is sufficient to enable water supplies to be obtained by developing catchments near the city. Some 33 square miles of the headwaters of the Moorarbool and Leigh Rivers suffice for the needs of Ballarat.

The scheme for supply to Bendigo and district, namely the Coliban scheme, is probably the earliest multi-purpose project in Victoria, water being supplied to towns and for commercial irrigation. It was originally contended that as the alluvial mining diminished, the additional water made available could be used for irrigation. This had the usual appeal of a multi-purpose project, an appeal inherent in the Snowy scheme which is valuable both from the power and irrigation viewpoints.

Irrigation

As irrigation accounts for about 90 per cent. of the water used in Victoria, and about half of this is supplied by the Goulburn System, the estimate of water usage for Victoria may be based on a recent analysis of the regulated output from this system. This analysis showed that a regulated output of 1¼ million acre ft. per annum could be obtained at headworks with the existing storages. For the State as a whole the regulated output for irrigation can be estimated

at about double this figure or 2½ million acre ft. per annum, and adding another 10 per cent. for evaporation, and a further 10 per cent. for other usage, the total utilized is about 3 million acre ft.

This output comes from storages of a capacity of 6 million acre ft. in streams whose mean annual flow also equals 6 million acre ft., thus giving a regulated output of 50 per cent. of the mean annual flow. This percentage is a fair average for Victorian streams. To obtain the same degree of regulation on all Victorian streams would therefore require an additional storage capacity of about 10 million acre ft. It is clear that present available water resources can be much further developed.

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.

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,

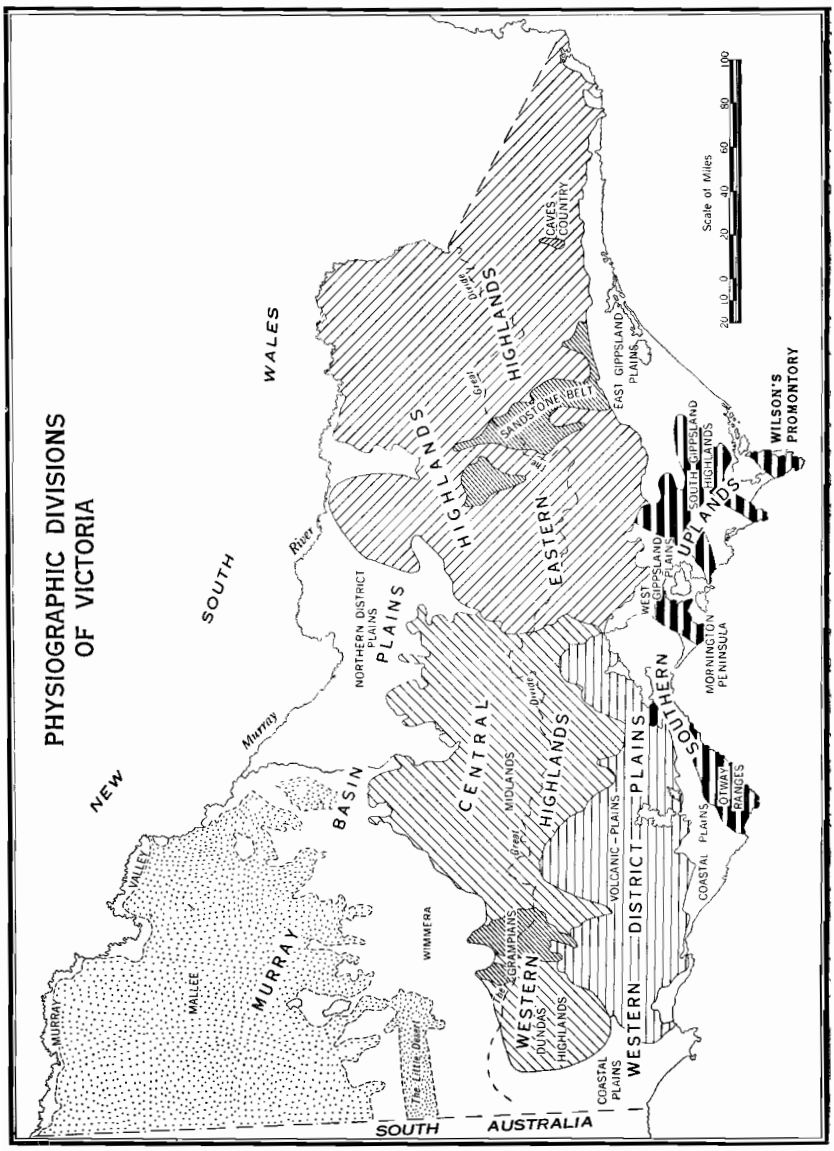

PHYSIOGRAPHIC DIVISIONS
OF VICTORIA
NEW SOUTH WALES
Murray River
BASIN
MURRAY VALLEY
MALLEE
MURRAY
WIMMERA
The Little Desert
NORTHERN DISTRICT PLAINS
CENTRAL PLAINS
MIDLANDS
Dividing Range
HIGHLANDS
EASTERN HIGHLANDS
Great Dividing Range
CAVES COUNTRY
SANDSTONE BELT
EAST GIPPSLAND PLAINS
SOUTH GIPPSLAND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

FIGURE 2.

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
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.

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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.

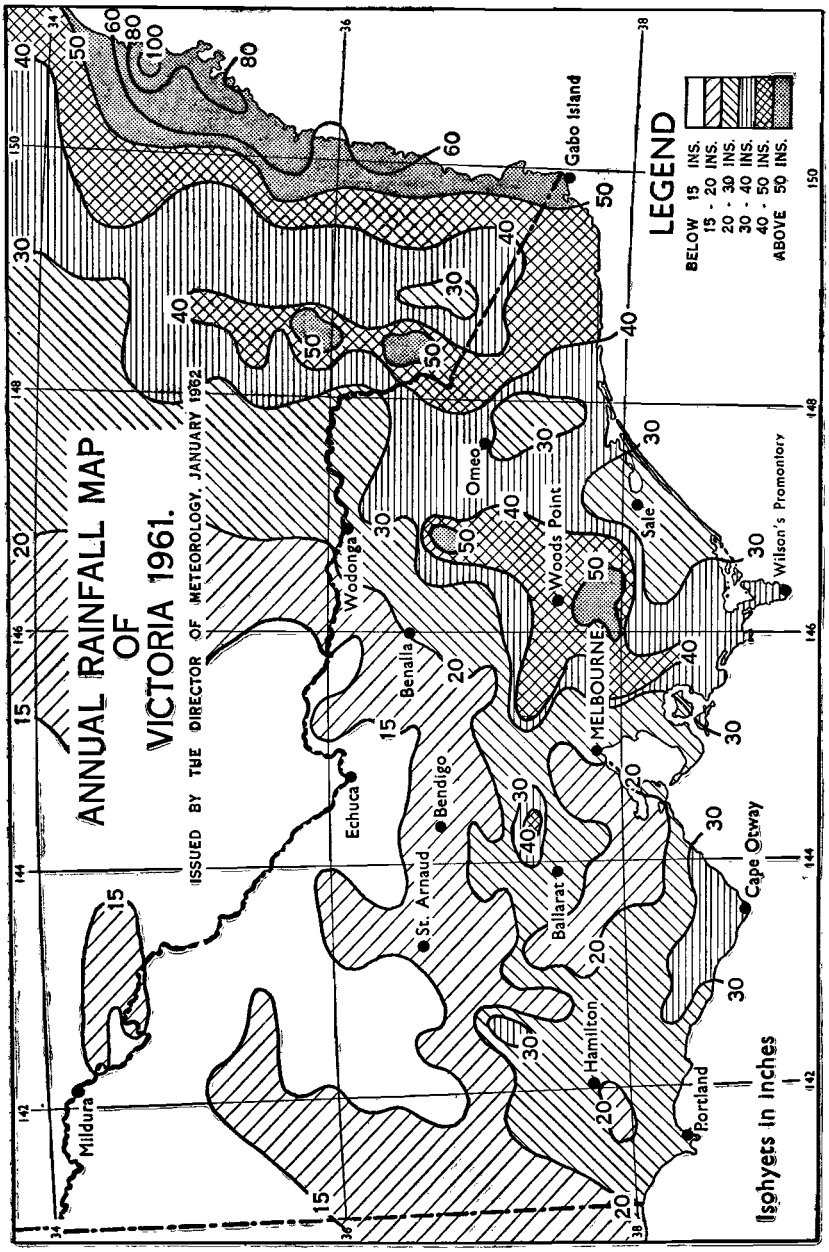
ANNUAL RAINFALL MAP
OF
VICTORIA 1961.
ISSUED BY THE DIRECTOR OF METEOROLOGY, JANUARY 1962
LEGEND
BELOW 15 INS.
15 - 20 INS.
20 - 30 INS.
30 - 40 INS.
40 - 50 INS.
ABOVE 50 INS.
Isohyets in inches
Mildura
Echuca
Wodonga
Benalla
Bendigo
St. Arnaud
Ballarat
Hamilton
Portland
Cape Otway
MELBOURNE
Omeo
Woods Point
Sale
Wilson's Promontory
Gabo Island

FIGURE 3.

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.

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, north, and lower north. 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.

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.

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 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 per 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.

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,

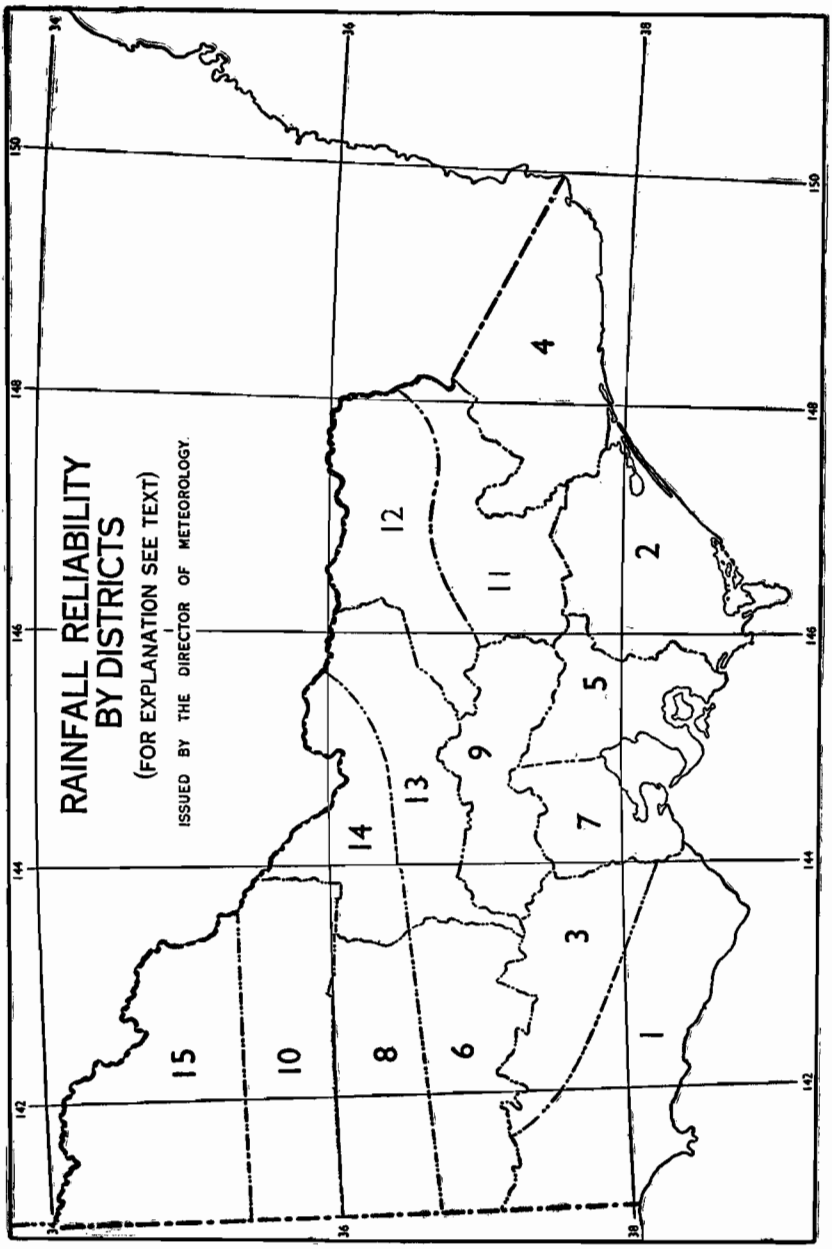

FIGURE 4.—Relative rainfall variability based on district annual rainfall. Names of districts are shown in table on page 54.

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 per 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 per 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 per month 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—in 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 per 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

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 per 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 with lulls, during which the speed may drop to or near zero, and 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 1961

Summer

For the greater part of the State this season was a dry one. Apart from East Gippsland, most places only recorded half their average summer rain.

The summer was very warm with both the maximum and minimum temperatures above the average for all districts. There were many occasions throughout the season when days were above 90° F., and a number of times temperatures exceeded 100° F. Generally speaking,

there were no extremely high registrations, the highest being 111° F. at Nhill towards the end of January. In Melbourne the summer was the sunniest on record.

Although the summer was dry and hot and the fire risk was high, the State escaped major bushfire outbreaks. One of the largest fires occurred in the Redesdale–Metcalfe area where some 10,000 acres of grass and scrub land were burnt, destroying houses and stock on 23rd January. A fire in the Pyalong district on 12th February also burnt about 10,000 acres of grazing property and stock losses were heavy.

Autumn

The over-all picture presented by the autumn was quite a favourable one and showed out all the more favourably in comparison with the autumn of 1960.

During the first week of March a storm located about the south-east of the Continent brought flood rains to East Gippsland. Club Terrace recorded 8·3 inches for this week, and Bairnsdale 5·2 inches in 24 hours. In East Gippsland several areas were flooded, some highways and roads were out, and several towns were temporarily isolated.

Although scrub and grass fires were reported during the latter half of March, these were of a minor nature and soon brought under control. A general rain early in April subsequently allowed all fire restrictions to be lifted. About the end of March severe thunderstorm activity in northern suburbs of Melbourne was associated with violent hail storms in the Sunshine–Deer Park area. Hail the size of pigeon eggs smashed windows ; there was local flooding ; and some factories were forced to cease production temporarily. Damage amounted to thousands of pounds. In the Heidelberg area 134 points of rain fell in fifteen minutes with a total of 183 points in half an hour.

The excellent rain which fell during April throughout the cereal growing district provided one of the best openings of the season ever experienced.

By the end of May, practically the only wheat crops not sown were those in areas such as the southern Wimmera and the Western District which are not normally planted until June. Dry conditions during May provided an excellent opportunity for sowing seed. However, further rain was needed to germinate seed and promote growth in the north. Conditions throughout the vine areas in the north were ideal for fruit drying.

Winter

The winter of 1961 was comparatively mild and generally well behaved. Maximum temperatures were above normal at most places throughout the State. In the south, minimum temperatures were well above the winter normal and near normal in the north.

The north-west quarter of Victoria which takes in most of the wheat-growing areas was the driest part during winter. Although the rainfall received in this quarter was only about three-quarters of the winter average, falls were timely enough to keep the wheat crop in a fairly good condition.

The winter rainfall in East Gippsland was almost one and a half times the winter average. Over the remainder of the State, rainfall was within about 10 per cent. of the average.

By the end of winter, crops were in a promising condition. However, the subsoil was dry in the wheat-growing areas and good soaking rains were needed.

Spring

The mild temperature trend which had been established in the previous season continued throughout spring. Maximum and minimum temperatures over the State were close to normal in a few districts but mostly they were well above the spring average.

The most disappointing feature of the year was the failure of the spring rains over the greater part of Victoria. The only two districts to receive rainfall that was average or above, were the Mallee and East Gippsland. The failure of spring rainfall was most noticeable in the Port Phillip Region.

Although the future of the wheat crop looked promising at the end of winter, there were not sufficient reserves of moisture in the subsoil and the failure of follow-up rain during spring caused crops to deteriorate rapidly. Harvesting commenced much earlier than usual in many areas. The position was further aggravated by abnormally high temperatures.

At the end of spring, it was estimated that the wheat yield this year would be well below the total for the previous year. As the acreage sown this year was much greater than previous years, the yield per acre represented one of the lowest yields for some years. The dry weather during spring also caused a set-back to many vegetables and fruit crops, and irrigation became necessary much earlier than usual.

Stock maintained good to excellent conditions as pasturage was ample ; however, it had dried off considerably by the end of spring. Generally speaking, water was in good supply although some storages were well below the normal at the end of spring.

Predominantly dry and sunny weather continued into December. Reservoirs which supply the Port Phillip Region were at the lowest levels they had been for about 50 years. Water restrictions were necessary in the city and suburbs early in December to conserve the dwindling water reserves. The year ended as one of the warmest and sunniest years on record for many places—particularly around the Port Phillip Region.

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 are shown the rainfall for each district and for the whole State for each of the years 1952 to 1961, together with the average rainfall covering a period of 30 years :—

VICTORIA—RAINFALL IN DISTRICTS

(Inches)

Year Ended 31st December—	Districts								Whole State
	Mallee	Wimmera	North-ern	North-Central	North-Eastern	Western	Central	Gippsland	
1952 ..	15·22	21·87	21·86	35·56	46·24	39·30	40·66	48·71	32·75
1953 ..	12·27	19·62	16·81	28·69	35·57	30·40	30·75	35·29	25·38
1954 ..	13·41	17·68	21·22	29·88	35·58	25·92	30·93	34·02	25·02
1955 ..	17·68	22·44	26·00	35·99	49·05	32·40	34·12	33·86	30·24
1956 ..	20·85	24·31	31·45	41·17	55·59	34·02	34·29	44·25	34·69
1957 ..	9·67	14·87	13·55	23·01	27·32	26·82	24·85	31·98	21·03
1958 ..	15·45	17·65	21·40	31·57	37·78	29·05	28·99	35·42	26·35
1959 ..	9·97	15·16	16·56	26·09	27·69	24·46	26·53	33·63	21·70
1960 ..	18·08	24·75	22·70	38·45	40·16	36·01	34·98	37·26	30·42
1961 ..	13·44	15·07	14·90	25·27	27·60	24·03	22·90	33·04	21·67
Averages*	12·49	17·52	18·09	28·16	34·81	27·59	28·89	33·47	24·30

* 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 1961 recorded in various Victorian country centres :—

VICTORIA—MONTHLY RAINFALL AND MEAN TEMPERATURE OF SELECTED CITIES AND TOWNS, 1961

Locality	Particulars	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ballarat	Rainfall (points) ..	28	94	274	356	103	243	302	237	135	257	97	116
	Temperature °F. ..	70·1	65·6	61·3	57·3	49·2	47·3	44·5	46·9	51·1	56·0	58·7	63·1
Bendigo	Rainfall (points) ..	42	82	286	308	70	178	219	111	104	134	88	335
	Temperature °F. ..	75·5	70·8	66·5	60·2	51·1	48·8	47·2	49·1	54·3	61·1	64·4	69·1
Colac	Rainfall (points) ..	36	29	110	364	180	450	320	269	141	231	140	210
	Temperature °F. ..	69·7	65·5	62·9	58·3	49·7	49·1	46·1	48·3	51·5	54·9	59·1	62·5
Geelong	Rainfall (points) ..	10	125	149	173	134	196	120	167	70	141	75	169
	Temperature °F. ..	70·9	68·2	64·9	59·9	53·8	52·0	49·4	50·7	54·7	59·7	62·3	66·1
Hamilton	Rainfall (points) ..	24	51	33	505	165	268	291	241	210	175	107	166
	Temperature °F. ..	71·5	67·4	63·7	59·5	51·8	50·3	47·3	49·1	53·3	56·8	60·9	63·9
Horsham	Rainfall (points) ..	10	79	90	275	84	99	194	66	141	119	123	153
	Temperature °F. ..	77·1	72·0	67·5	61·5	53·0	50·1	47·5	50·0	55·2	61·3	65·7	70·0
Mildura	Rainfall (points) ..	51	42	71	127	34	33	105	43	112	38	308	201
	Temperature °F. ..	79·3	75·3	70·5	64·5	55·7	53·3	50·2	51·9	59·1	65·5	68·2	73·0
Sale East	Rainfall (points) ..	253	70	524	171	163	164	417	274	211	283	101	112
	Temperature °F. ..	68·2	67·1	63·9	59·2	50·9	50·3	48·6	49·1	53·1	59·3	60·8	65·3
Wangaratta	Rainfall (points) ..	45	56	200	224	59	156	230	330	187	110	191	107
	Temperature °F. ..	75·6	72·1	67·7	61·1	51·1	48·5	46·6	48·4	53·2	62·0	66·3	71·1
Warrnambool	Rainfall (points) ..	36	73	93	494	209	317	273	253	236	177	131	323
	Temperature °F. ..	68·3	64·3	63·2	60·1	54·5	52·7	50·1	51·5	55·1	58·5	60·1	62·1

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 1957 to 1961. 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	1957	1958	1959	1960	1961
Atmospheric Pressure (Inches)—					
Mean	30·018	30·015	30·080	29·996	30·050
Highest	30·650	30·522	30·669	30·570	30·620
Lowest	29·452	29·451	29·233	29·157	29·367
Range	1·198	1·071	1·436	1·413	1·253
Temperature of Air in Shade (°F.)—					
Mean	58·7	58·3	59·5	58·8	61·1
Mean Daily Maximum ..	68·1	66·6	68·4	67·6	70·4
Mean Daily Minimum ..	49·4	49·8	50·7	50·0	51·9
Absolute Maximum	103·0	101·7	109·0	105·0	107·0
Absolute Minimum	30·8	32·3	29·5	31·3	33·4
Mean Daily Range	18·6	16·7	18·4	17·5	18·5
Absolute Annual Range ..	72·2	69·4	79·5	73·7	73·6
Terrestrial Radiation Mean Minima (°F.)	46·0	46·8	47·5	45·9	48·2
Rainfall (Inches)	20·86	26·98	25·84	33·50	22·05
Number of Wet Days	146	156	131	162	129
Year's Amount of Free Evaporation (Inches)	41·40	38·75	38·43	41·44	42·17
Percentage of Humidity (Saturation = 100)	62	66	65	65	63
Cloudiness (Scale 0 to 8)* ..	3·7	4·8	4·6	4·9	4·4
Number of Days of Fog ..	18	21	24	21	18

* Scale : 0 = clear, 8 = overcast.

An estimate of the areas of the State, subject to different degrees of average annual rainfall is contained in the following table :—

VICTORIA—DISTRIBUTION OF AVERAGE ANNUAL RAINFALL

Rainfall	Area
inches	square miles
Under 10	Nil
10 to 15	19,686
15 to 20	13,358
20 to 25	15,731
25 to 30	15,819
30 to 40	14,150
Over 40	9,140