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VICTORIA AT THE TIME OF SETTLEMENT*

INTRODUCTION

Between 1962 and 1975 the *Victorian Year Book* included a special article describing an aspect of Victoria's physical environment each year except that in 1973, which was the centenary of the *Year Book*, the whole treatment of Victoria's development was in fact historical.

The general approach to each of these articles about the physical environment was systematic in the sense that it sought to give a factual outline of the subject and, with the aid of bibliographies, enable the reader to explore it further if he wished to do so. The treatment of the subject in each case being descriptive as well as systematic assumed that the author or recorder was in a sense an outside observer of the natural environment. At the time most of these articles were written this was a reasonable enough approach which had its antecedents in the teaching and writing of natural history over many years.

However, some time in the 1960s, a world-wide change of outlook took place in man's attitude to his environment and therefore changed this assumption. Partly arising from reflections about the effects of synthetic pesticides in the cycle of nature; partly from the growing debate on the relation of population growth and the available natural resources to sustain it; partly from an awakening reassessment of such basic resources as soil, water, and vegetation; and partly from a deepening study of man's total relation to his environment—as a result of these and many other factors, two new notes entered into the study of natural resources. These notes were the realisation that resources are basically finite, and that in future man and all his activities would have to be studied as an integral part of the milieu of nature. Any reliable description of the natural environment from now on would, in fact, have to include man no longer only as the observer but even more as the observed.

In Victoria the debate about the best way of using and protecting the inherited environment became increasingly vocal and widened to include quite novel groupings of people who began to warm to the theme. Behind the increasingly animated debates with their political overtones, there was, by the early 1970s, the articulation of two ideas: one, that careful thought would have to be given to the husbanding for future generations of resources that were by their very nature finite, and the other, that the environment (whether urban, suburban, or rural) had a profound effect, not previously expressed in a very conscious way, on what came to be called the " quality of life "—in other words, the factors other than material consumption, that contribute to make a community's life pleasing and worthwhile.

* This is the first of a series of major articles on Victoria's environment and man. Succeeding articles, planned for publication over several years, will take up many of the topics contained in this article.

These two ideas produced a significant shift in attitude toward the natural environment: a change of perception which may perhaps best be described as a transition from immediacy to a long range perspective. Already in the 1930s there were intimations of this in the concern shown about soil erosion in such areas as Victoria's Mallee and the consideration of possible remedies. Later, in the 1950s, a similar concern was shown for the management of fish and wildlife. By the 1970s the changed attitude extended to all forms of natural resources: land as the basic entity on which a community depends, soil, water, vegetation, wildlife, and minerals. Whereas the early settlers, naturally enough, saw all these resources from the stance of immediacy—after all, they had to find food, shelter, and clothing—the generation of the 1970s tended to have a hard look backwards at the way Victoria's resources had in fact been used. It did this not so much to castigate the errors of the past as to entertain reasonable expectations of the future. This new conjunction of perspectives posed many quantitative questions and demanded answers. On such topics as land and resource use over various geographical scales, the answers still await, and will depend on, extensive research.

A corollary to this new perspective of studying the past for an understanding of the future was the volatile question of competing resource uses. Given the finiteness of natural resources in a community and an increasing knowledge of their dispersement in the past, how can a government balance the claims of development with those of preservation? How does contentious debate yield to rational policies? The difficulty of these questions is not surprising since the questions are neither isolated nor confined merely to natural resources: they are inextricably bound up with population growth and dispersal, political philosophies about what defines the quality of life and the underlying economic needs which must sustain it, wider national economic policies, the aesthetics of landscape preservation, and the best balance between privately and publicly owned resources.

Many contributions will doubtless be made in the future to the elucidation of this extensive problem. The series of articles to be presented in this and future *Year Books* under the general title of "Victoria's environment and man" will have a modest aim. They will seek to describe how man has used many of Victoria's resources and what effect he has had on their configuration as a result of disturbing the pristine stability of land, water, vegetation, and wildlife. Conversely, they will also seek to show how the climatic elements including fire, flood, and drought have affected man's attitude to his environment which has also, in turn, prompted his attempts to regulate the destruction, depletion, and eventually reclamation of resources.

The focal point of this new series of articles will be the interaction of man with his environment in Victoria. In so far as they will place man squarely in the spectrum of the natural environment, it is hoped the articles may shed some light on how Victoria has evolved towards its present ecological configuration.

PATTERN OF SETTLEMENT

Between the first counting of the people in 1836 and the Census of 1851 the population of the Port Phillip District of New South Wales (later to become Victoria) increased from 177 to 77,345 not including Aboriginals. The next decade saw a rapid increase with the inflow of people attracted by the discoveries of gold, so that by the 1861 Census the population (again excluding Aboriginals) was 538,628 and while most people were to be found in Melbourne and the gold mining centres, almost the whole of Victoria except for the Mallee and the most mountainous areas had been populated. In slightly less than thirty years almost the whole of the country at present occupied had been settled.

When in the 1830s the first settlers began to occupy the Port Phillip District, most of the problems that had worried the earliest settlers near Sydney were, if not solved, at least understood. Midsummer in January and midwinter in July were no longer novelties and though the debate as to whether calving and lambing should best occur in autumn (corresponding with the northern hemisphere spring) or in spring continued, it was no longer important. Except perhaps in Monaro, the Australian winter was not severe enough to be any greater threat to small animals than the hot dry summers, so graziers followed their own inclinations or prejudices and were, on the whole, equally successful whichever season they chose. The greatest climatic problem was that of seasonal drought, and the fact that the rains were not only less frequent and less reliable than those of Britain, but also that they might fail in occasional seasons, was accepted and guarded against as far as possible by the establishment of runs on rivers that offered a near permanent water supply.

Trees were no longer regarded as an indicator of soil fertility. Experience had shown that heavy stands of timber might occur in thin stony soils as well as on deep ones and that the grassy, thinly timbered "forest lands" (the open eucalypt woodlands, which were so frequently compared to the British nobleman's park) were equally well suited for agriculture as for grazing, and that for agriculture they could be more quickly and easily cleared than areas more thickly timbered. Their soils gave diminishing returns after a few years' cropping, but so did most of the Australian soils, and while the supply of land seemed unlimited, this caused no real problem as new areas could be brought into cultivation. Declining fertility remained a problem until it was realised that it stemmed from a phosphorus deficiency that could be reduced by the use of superphosphate fertilisers.

By the 1830s the problem of finding marketable produce had also been solved. As European populations were increasing, foodstuffs offered European farmers a better return than wool and even though the demand for wool was increasing as industrialisation made wool textiles cheaper and more readily available, European wool production was declining. Though in some ways Australian wool was inferior to European wool, it was better than none and during the 1820s was bought in increasing quantities by British manufacturers. Often the Australian wool producer had to wait a long time for payment for his wool, for transport both from his run to a port and from the port to the British market was slow, and his payment after his wool was sold travelled equally slowly. Meanwhile he could live cheaply on damper, mutton, and tea; sell, at reduced prices, to local speculators; or rely on banks or merchants for credit until his cheque arrived. Nearer at hand increasing numbers of convicts, especially in Van Diemen's Land, opened a growing market for meat that could not be supplied locally.

Thus by the 1830s the prospects of making a living by grazing sheep and cattle had spread settlement far beyond the original nineteen counties of New South Wales and over the most suitable parts of Van Diemen's Land and the graziers in both colonies began to look to the Port Phillip District that lay between as an area for expansion, and despite governmental disapproval, began to infiltrate the district from both north and south. Two streams came south: one from the Monaro through the mountains and high plains towards Gippsland, and one across the Murray to extend south-westerly along the foothills of the ranges between the more rugged country to one side and the wide plains of the Murray's tributaries on the other. Two streams crossed Bass Strait to establish themselves around Port Phillip Bay and in the Wannon valley to the north of Portland. Very quickly these streams met and merged and Sydney-siders were to be found close to Port Phillip and in the Western District, while Van Diemonians pushed northwards towards the Murray—both believed in better pastures farther out.

By the 1840s a broad band of country running from north-east to south-west, from the Murray to the Western District had been occupied. Within it isolated patches that were rugged, or swampy, or heavily timbered, or poorly watered had been avoided, while beyond it to the north-west isolated runs had been established in the Wimmera and to the south-east in the high plains and around the lakes in Gippsland. Except around Port Phillip Bay where about half the population was concentrated, settlement was sparse and thinly spread. Whether they grazed sheep or cattle the squatters required large areas for their sheep walks or cattle runs, and if neighbours were few there was more room for expansion as flocks and herds multiplied. Apart from Melbourne, Geelong, and Portland, "towns" hardly existed though a scattering of inns and taverns, doubling to some extent as stores, provided minimal accommodation and supplies for travellers and copious quantities of liquor for both travellers and local residents. In many cases these hotels provided a nucleus around which towns would grow later.

In the early 1840s a steady demand for wool in Britain, for meat in Van Diemen's Land, and perhaps equally important, for livestock to stock the new runs that were continually being occupied meant that the graziers did well. The late 1840s, however, saw an economic recession with falling prices and many, especially those who had not yet had time to establish themselves or who had relied too much on the support of banks or money-lending merchants, were forced to sell their stock for whatever it would bring and seek employment.

Agriculture had developed more slowly and in the early years was confined to the areas immediately to the north of Melbourne and in the vicinity of Geelong in the Barrabool Hills and Bellarine Peninsula. Only in Melbourne and Geelong were there populations large enough to create a market for agricultural produce paying prices high enough to meet costs of clearing and production and transport over relatively short distances. Generally it was the Sydney-siders who engaged in agriculture, because they were able to bring their assigned convict servants and so had access to cheaper labour than the Van Diemonians who had to employ free men demanding higher wages and preferring to work as shepherds or herdsmen rather than agricultural labourers. The rapid exhaustion of the soil and the continual necessity to clear new land for cultivation kept the cost of production of crops high, so that locally produced grain was more expensive even in Melbourne than grain imported from Van Diemen's Land or South Australia.

The influx of people with the gold rushes of the 1850s brought some benefits and some difficulties for Victorian farmers. Labour became more expensive as freemen sought their fortunes on the goldfields and the numbers of shepherds and herdsmen on the runs were reduced to compensate for their higher wages. The use of sheepdogs became more common and the washing of sheep before shearing was abandoned. The greasy wool brought lower prices than washed wool, but the difference was not sufficient to warrant the increasing labour costs of washing. However, the growing population increased the demand for foodstuffs and both agriculturalists and graziers found ready markets for crops and meat and, despite the payment of higher wages, both activities became more profitable. Agriculture was established around the larger goldfields, especially near Ballarat and Bendigo, and graziers moved further out, so that by 1860 almost the whole of Victoria apart from the Mallee and the ranges of the Otway Peninsula, the Alps, and Gippsland, was subject to settlement. Feeding goldminers was a surer source of wealth than mining.

With increased population there was a greater demand not only for food but also for clothing, for carts and wagons, for picks and shovels, for ploughs and all kinds of mining and farming implements, for saddles and harness, and manufactured goods of all kinds. As a result, production of those things that could be made in the Colony was increased and in Melbourne, Geelong, Ballarat,

and Bendigo, workshops and small foundries began to multiply. The economy was becoming more diversified even though the Colony still relied heavily on imported manufactured goods. But increasing prosperity was making possible the planning of railways to speed and cheapen the movement of goods, and incentives for manufacturers to establish themselves in the Colony. The improved profitability of farming was bringing demands for the squatters' grip on the land to be loosened, and for free selection Acts to open the way for more widespread cropping. This move was to some extent supported by the squatters themselves, as they required a firmer hold on their runs than their licences afforded if they were to continue to make the improvements in fencing, in shearing sheds and equipment, in wells, and windmill pumps, that were becoming increasingly necessary to help reduce the numbers of workers whose wages were rising.

The towns were growing too. Melbourne was beginning to spawn suburbs that were spreading around the first centre. Land sold in 10 and 20 hectare blocks in the 1840s was being subdivided into residential plots and the present "inner suburbs" particularly Prahran, Richmond, Collingwood, Fitzroy, North and South Melbourne, and the southern part of Carlton were extending and growing in population. The "small, mean habitations" of these suburbs contrasted with the "charming villas" being built in South Yarra, St Kilda, Hawthorn, Kew, and Essendon. The building industry was becoming the most important single secondary industry in the Colony. The local basalt was not easy to work and though it provided the material for some of the more substantial buildings, the cost of working it led to its use only for the foundations of more modest structures. The shortage of good timber close to the city meant that timber and even prefabricated buildings of wood or iron were imported. Governor La Trobe's cottage and Bishop Perry's church are notable early examples of imported prefabricated buildings, and they were followed by a theatre and innumerable houses of wood or iron ranging from modest cottages to extravagances like Corio Villa at Geelong.

Though by 1861 most of Victoria had been occupied its population was concentrated, as it still is, in the area surrounding Port Phillip Bay. Melbourne's population was 139,916 and Geelong's about 23,000. The goldmining centres were the other large concentrations of populations: Ballarat 22,000; Bendigo 13,000; Castlemaine–Chewton 13,000; Creswick almost 5,000; Maldon over 3,000; and Inglewood, Maryborough, Beechworth, and Amhurst between 2,000 and 3,000. Altogether about 42 per cent of Victoria's population were in the gold towns or on the diggings. The remainder of the population was still spread thinly and widely with rather more in the Western District than in northern Victoria and Gippsland. The Colony's sheep and cattle were also concentrated more in the Western District and the counties surrounding Port Phillip Bay than elsewhere. Its agriculture, like its population, was found chiefly around Port Phillip Bay and the goldmining centres.

In the 1860s Victoria was poised to begin a period of development that was to culminate in the boom of the 1880s. The country had been occupied but chiefly by pastoralists and graziers. The 1860s were to see the passing of the free selection Acts and the beginnings of railway building that together made possible the spread of agriculture and the development of wheat growing. The graziers had already experienced the occasional drought that was to lead to plans for water conservation and irrigation projects later in the century, and the first industrialists were already established in Melbourne, Geelong, Ballarat, and Bendigo. Although the great developments in agriculture, irrigation, and industry were still to come, and although the population was still small, already settlement was modifying the environment. Grazing had changed the character of the natural pastures: the most palatable species were being eaten before they could set their seed, and so gradually disappearing, while the less palatable species were beginning to dominate pastures. Forests near the towns

were being cleared for firewood and building timber as well as to make way for agriculture. Tanneries and abattoirs were beginning to pollute the Yarra River as was Melbourne's rudimentary sanitary service. Destruction of the natural environment was the natural and inevitable consequence of development. As the pace of development increased so too did the rate of its modification of the landscape.

CLIMATE

When John Batman left Launceston for Port Phillip on 10 May 1835, it took him until 27 May to escape from the coast of Van Diemen's Land. He was held up by gales from the north and west, but was then able to make the crossing in two days in light winds. In November of the previous year, Edward Henty was within 8 kilometres of Portland Bay when a gale of wind came away from the west-north-west and blew him back to King Island. Indeed it took him 34 days in all to reach Portland Bay. Earlier still, Captain Cook, on the day before Point Hicks was sighted, experienced a southerly gale, and his run from Point Hicks to Cape Howe was accompanied by strong south-west winds, showers, and waterspouts. It was not surprising that Bass Strait and the Victorian coast established a reputation for gales and rough seas.

Gales and storms as such were no strangers to mariners who came from the northern hemisphere and in any case had sailed most parts of the globe. But the hot winds on land were a new phenomenon to settlers from Britain. They were remarked upon and the days of their occurrence specially noted in early weather records. The wind was made more unpleasant near places of settlement by great quantities of dust raised from unsealed roads and quarries, and was sometimes called a brickfielder.

Bushfires were found to be a dangerous phenomenon on days of hot wind. In the first summer of settlement, Edward Henty noted that the year 1835 opened with many fires in the bush, fanned by a hot north wind. Bushfires had been endemic before the arrival of the white man, but most probably not on the scale of the holocaust of 6 February 1851 when much of Victoria was burnt, with great loss of human and animal life. The heat of the Victorian summer sun was a new experience for those who had not left Britain before. Many office workers, unused to manual labour, found the hard work of digging for gold under the hot summer sun too much. Dr Lang had unrealistically likened Victoria's climate to that of Devonshire. Howitt agreed with Strzelecki who thought it to be more like that of Naples. It was the great diurnal range in temperature in summer which affected the health of those camping in the open, particularly in the highlands where the goldfields were situated.

Some goldfields had to be abandoned in the summer months because the creeks supplying the necessary water had dried up. Drought, which in England could mean a period of a fortnight or so without rain, in Victoria meant a period of many months when rainfall was very low. At other times there was too much water. Heavy rain from thunderstorms could cause flash flooding of creeks. Prolonged heavy rain caused widespread flooding and damage.

The changeability of Victoria's weather particularly in the spring months impressed itself on the early settlers. Western Europeans were used to variability in the weather from day to day, but the contrasts in temperature are greater in Victoria. Howitt, for example, described a sequence over a few days in October of frost, heat, thunderstorms, and then "cold as winter". The summer cool change was particularly noticeable, when the temperature would fall between 10°C and 15°C in less than half an hour. The first settlers established farms at Portland and around Melbourne, districts which have the most reliable rainfall in the State. Even so, the dry weather and high evaporation of summer leads to wilting and drying off of grass. Fodder has to be conserved to cover the dry spell of summer as well as the lack of growth in winter.

As settlement moved into northern Victoria, the dry, brown landscape of summer came to be recognised as a normal feature. Had Major Mitchell made his march in January instead of August, he may not have described the country as "Australia Felix".

Although the general feature of the climate of Victoria has remained unchanged over the period of European settlement, the microclimate has been changing in some ways. The growth of Melbourne has caused an increase in daily minimum temperatures near the centre of the City. The annual mean minimum temperature has risen from 9.4°C over the years 1863 to 1882 to 10.6°C over the years 1955 to 1974. This heat island effect is common to large cities throughout the world.

The incidence of frost can be a very localised phenomenon, and can be affected by man's activities. Hedges across the slope of a hill impede the downward flow of cold air, and frosts occur on their upslope side. Frost damage in orchards can be prevented by the use of smudge-pots or water sprays.

The theory that deforestation leads to decreased rainfall has been debated for a century, but no conclusive evidence has been found to support the view. Most rainfall records begin with settlement which is co-incident with clearing of the forests, but an examination of rainfall records in South Gippsland, where once heavily forested hills have now been completely cleared, show no systematic trend of either decreasing or increasing rainfall.

Although man has been unable to affect the amount of rain that falls, he has been able to alter its effect in some ways. River works have lessened the severity of flooding. Water storages have been built, which help to control river flow, and more importantly provide water for irrigation of areas where rainfall is deficient or variable.

FIRES

The records of fire in Victoria and the effects on the natural and social environments were poorly documented before 1883 when Edward M. Curr's *Recollections of Squatting in Victoria (from 1841 to 1851)* was first published. There are some references to the occurrence of fire in Victoria prior to that decade, but they are sketchy. However, there is evidence from elsewhere in Australia which is generally relevant and which is worth reviewing in order to postulate the role of fire in both the past and present Victorian environment.

In the seventeenth century several navigators sailed the west coast of Australia and recorded smoke and evidence of widespread fires on land. For example, Dampier in 1699 saw many fires on the mainland and on islands off the West Australian coast. Later, Cook and Banks made numerous references to smoke on the mainland during their voyage along the east coast of Australia in 1770. Further south, Tasman in 1642 recorded various fires burning in Tasmania.

The first settlers and explorers made more numerous and detailed records of fires, including the first reference in February 1788 to lightning causing a forest fire. They also described the practice of the Aboriginals to set fire to large areas of country.

Curr's writings show a notable understanding of Aboriginals and the ecology of the country in northern Victoria. He describes the accidental and systematic burning of grass and trees by Aboriginals and attributes many of the important natural features such as "the character of our vegetation and its scantiness; the retention within bounds of insect life (notably of the locust, grasshopper, caterpillar, and moth) . . ." to periodic burning.

Lightning causes large numbers of fires each year, and there is no doubt that if fires were allowed to spread unchecked they would burn large areas whenever and wherever there was dry fuel. This would also have been so before European settlers arrived. This fact, as well as the actions of the Aboriginals suggests that fire has been widespread and frequent throughout the continent for thousands of years.

The vegetation over most of Australia is consistent with this conclusion. It is particularly well adapted to survive and even thrive in a fire environment. For instance, most eucalypts have thick bark which protects the cambium from heat, dormant buds on the trunk, and branches which produce new leaves if the tree crown is destroyed, and lignotubers which produce new basal stems if the main stem is destroyed. The few eucalypt species, such as Mountain Ash in which these features are absent or poorly developed, adapt to fire by the ability to regenerate prolifically in the full sunlight on the burnt seed bed beneath the fire-killed stand. Other flora such as Acacia, Banksia, Xanthorrhoea, Poa, and many of the Orchidaceae and Epacriaceae, through structure of the fruit or stem and root systems, are able to survive or recycle following periodic burning.

The frequency with which any one area was burned in historic times has varied considerably. The pockets of rain forests were not burned at all. The wet sclerophyll forests burned occasionally when sufficient fuel ignited in an exceptionally hot dry summer. This vegetation type is adapted to burning at intervals between once every thirty to once every three or four hundred years. In the dry Mallee forests the frequency was probably also low because there was very little fuel to burn. In the dry sclerophyll and woodland forests where good winter and spring rains produced abundant fuel which dried out each summer, fire frequencies of three to thirty years were likely.

Colonisation by Europeans produced definite changes in the pattern of fires in Victoria and also in their effects. Burning to clear land and to promote fodder for sheep and cattle was common practice last century and early this century. It frequently resulted in fires escaping into adjacent forests and, at least in the wet sclerophyll forests, it increased the frequency with which they were burned. In many cases this produced changes in the character of the vegetation, which is still evident today.

Colonisation also introduced new values into the country including houses, fencing, stock, and human life. The effect of uncontrolled fire on these values was far more dramatic than on the natural values of the land, and fire quickly assumed a new significance.

Widespread fires in 1851, 1886, 1898, 1901, 1914, 1919, and 1926 caused serious damage to stock and property and loss of life. In 1939, 71 people were killed by fires which destroyed sawmills, many houses, and hundreds of miles of fencing. In more recent years destructive fires occurred in 1944, 1951, 1962, 1967, and 1969.

The damage caused by fire to social values, particularly in 1939 and 1944, caused significant changes in the attitude of people and governments to fire. It resulted in major changes in fire legislation and a re-organisation of all aspects of fire control.

This up-grading of fire control has now resulted in areas of burnt country which are less extensive than those of the nineteenth century and the era before settlement. However, although this success has resulted in less frequent fires, the fires that have occurred have been more intense and damaging. The apparent reason for this anomaly is that in the absence of frequent widespread fires, the amount of flammable fuel in forests accumulates so that, when a fire does occur in hot dry weather, a great deal of energy is released quickly. It is then virtually impossible to control.

This paradox, whereby successful fire suppression has tended to defeat its own purpose, has affected current fire management practices that are now based on a total environment concept. This recognises, first, that fire is a natural part of the forest environment, that it can and should be used, not only to reduce fuel, but also to benefit specific ecological associations, and second, that fire should be suppressed at times and in places where its effects are undesirable or likely to become uncontrolled.

APPEARANCE OF "AUSTRALIA FELIX"

That portion of Australia now known as Victoria was virtually unknown before 1824. The exceptions were two or three coastal areas at which either explorers had stopped for a short time to replenish water supplies, or, in one case, where settlers tried to establish a farming community. Such names as James Grant on Churchill Island in Western Port in 1801, John Murray, the discoverer of Port Phillip Bay in 1802, and 32 years later, the Henty Brothers' settlement in Portland, the first permanent settlement in the Colony, come readily to mind.

These were all very localised intrusions on the southern perimeter of what was later to be known as the Port Phillip Settlement of the Colony of New South Wales.

Apart from one or two very minor comments and practical demonstrations made by Grant, Murray, and others on the potential of the areas along the coastline, nothing at all was known of the nature of the country inland from those areas. Certainly there had been reports in Sydney from escaped convicts, and some Aboriginals, that there was very beautiful and rich country to the south of the mountains, but these must have applied to New South Wales, and, in most cases, there was no supporting evidence at that time.

It was left to two well known expeditions—that of Hume and Hovell in 1824, and Mitchell in 1836—to provide some detail of what lay well beyond the southern boundaries of their time.

The expedition of Hamilton Hume and William Hovell in 1824, which cut a swathe from the north-east of the land south of the Murray River to the western side of Port Phillip Bay was a notable piece of exploration, but their diary, while commenting favourably on the possibilities of the country, throws very little light on anything else beyond vague descriptions of the mountainous and alpine regions, and certainly their comment on "cutting grass, impenetrable brush wood and immense quantities of dead timber" did not draw enthusiasm later in Sydney on the potential of the country.

However, it is from Sir Thomas Mitchell's expedition of 1836, his third into the interior of eastern Australia, that a great deal can be learned of what the southern land was actually like.

Details of his journey from the Murray River south westerly to Portland, and then northward through the Grampians to the Murray, are well documented in his journals. Mitchell, the Surveyor-General of New South Wales, was also a scientist and an accepted artist, and was well qualified to make accurate observations on the land through which he was passing. Many of these statements give some indication of how the country appeared and appealed to him. It was at the end of his journey, during which he was tremendously impressed with the character of the country, that he summed up his impressions: "The land is, in short, open and available in its present state, for all the purposes of civilised man. We traversed it in two directions with heavy carts, meeting no other obstruction than the softness of the rich soil; and, in returning, over flowery plains and green hills, fanned by the breeze of early spring, I named this region *Australia Felix*, the better to distinguish it from the parched deserts of the interior country . . ."

While space does not permit the inclusion of all the superlatives he used to intimately describe this area, certain of his comments are pertinent: "Every variety of feature may be seen in these southern parts, from the lofty alpine region on the east, to the low grassy plains in which it terminates on the west. The Murray, perhaps the largest river in all Australia, arises amongst these mountains, and receives in its course, various other rivers of considerable magnitude . . . Falling from mountains of great height, the current of these rivers is perpetual, whereas, in other parts of Australia, the rivers are too often dried up . . .". "Hills, of moderate elevation, occupy the central country,

between the Murray and the sea, being thinly or partially wooded, and covered with the richest pasturage". "Towards the sea coast on the south, and adjacent to the open downs . . . there is a low tract consisting of very rich black soil, apparently the best imaginable, for the cultivation of grain, in such a climate". "The high mountains in the east have not yet been explored, but their very aspect is refreshing . . . "

These statements, which are some samples of how he expressed and interpreted the nature and value of the country, combined with his constant references to the extent and the diversity of wildlife present, establish a picture of great physical beauty and variety of type, a land of great potential for farming and worthy of development. In other words, it would now be deemed a challenge for the conservation of its assets.

Following the return of Mitchell to Sydney, and the release of his report, a great exodus of squatters took place from that centre to *Australia Felix* to take up the best of the land there and turn large areas into pastoral holdings. Thus commenced the occupation and consequent partial despoliation (when compared with its original ecology) of this portion of Australia. The damage became more severe and critical because so little, if any, was known and therefore appreciated at the time, of the unusual natural history and ecology of this area.

This was not, however, a unique set of circumstances—it had happened previously in the initial development of many other countries. The late Sir Russell Grimwade, a former Chairman of Trustees of the National Museum of Victoria, gave expression in 1954 to the natural sequence of settlement: "There are both duties and obligations upon those of a civilised people who . . . enter a strange and almost empty land. The first duties consist of establishing . . . a landing where their occupation is secure and from whence sorties can be made inland to survey and explore new country. Once a man is housed against weather, has food in the larder, and can keep in touch with his neighbours, he has won to a position where he can begin to study his surroundings and to satisfy the inborn curiosity that is the prime cause of man's accumulated knowledge. The thoughtful man in a new country like this then becomes aware of his obligations to his successors and realises that his coming to a new land may cause permanent changes in his environment".

However, while it was in 1836 that Mitchell's explorations led to the opening up of the country for agricultural purposes, it was not until nearly twenty years later that the first organised efforts were made to determine accurately and comprehensively something of the natural history of the new settlement.

While a number of interested amateurs had made excursions to the outlying districts surrounding the recently formed Melbourne, and collected their own specialities, the first organised effort to co-ordinate these "surveys" did not take place until 17 June 1854, when the Philosophical Society of Victoria was founded. At meetings of this society, both professionals and amateurs came together to pool their results, mainly of the natural history of Victoria. Many of the specimens they collected found their way to the new Natural History Museum.

Among the earliest of these members were three scientists who were, almost at once, to commence expeditions to provide basic information for the study of conservation. These were:

(1) Baron Sir Ferdinand Jakob Heinrich von Mueller, appointed Government Botanist early in January 1853, who was to contribute greatly not only to botanical knowledge but also as an explorer, to information concerning the outlying parts;

(2) Professor Sir Frederick McCoy, appointed in 1854 first Professor of Natural History at the University of Melbourne and, in 1856, Palaeontologist of the Geological Survey of Victoria; and

(3) William Blandowski, who was appointed Government Zoologist at the Museum on 1 April 1854.

Baron von Mueller, immediately following his appointment as Government Botanist, set out with one of his colleagues, John Dallachy, on a journey of exploration to remote parts of the country hitherto unknown. They travelled with pack horses to the alpine areas of the previously unexplored Buffalo mountains, and climbed the highest peak which von Mueller named Mt Aberdeen (now the Horn). From there, von Mueller proceeded alone to Mt Buller, through parts of central Victoria, heading back to the La Trobe River, finally reaching the coastline between the Lakes and Port Albert, and then back to Melbourne. On this journey, he covered 2,400 kilometres and added nearly 1,000 species of plants to the official list.

This was but one of many exploration journeys made by von Mueller over the next decade into more or less unknown parts of the Colony, on every occasion adding to the flora list. It was this very early work of von Mueller that provided the basic check list which students of conservation can use more than a century later for their studies on the effect of agricultural development on the balance of native plants, which led in some cases to the extermination of species.

What von Mueller carried out for botany, Blandowski performed for the zoology of the area. His first field work, commenced on 27 June 1854, was carried out in the central parts of Victoria, particularly in those areas around Mt Macedon, McIvor, and the Black Ranges on the Upper Goulburn River. His report on this trip is an important document, covering the fields of physical geography, geology, zoology, and ethnology, and providing basic information on areas rarely if ever visited before that time.

The expedition which, however, provided some of the most important fundamental information was his "Lower Murray River Region Expedition" which left Melbourne on 6 December 1856, and covered, using pack horses, over 2,000 kilometres, examining a wide area on each side of the Murray River from Echuca westwards. This party collected over 16,000 specimens, much of the material being new to science. However, a fact probably more important than any other for the study of modern conservation, was that this expedition collected a number of native mammals that later rapidly became extinct in the area. These included a species of native cat, a phascogale, a bandicoot, a wallaby, and several species of native rodents. Fortunately, the original specimens gathered are still in the collections of the National Museum of Victoria.

While Sir Frederick McCoy is always praised for his professorship at the University of Melbourne and his work as Director of the National Museum, it was in his position as palaeontologist to the Geological Survey that he made his contribution to the basic knowledge of geology in its widest form in the very early years of Victoria. Much less spectacular than the work of von Mueller and Blandowski, its impact was to be ranked equal in that it provided basic material of that stage of the past. It also allowed comparisons to be made of the effects of the immediate past and the present, and so possibly provide guidelines for those of the future, in order to reduce to a minimum the impact of modern and future civilisation. McCoy also contributed to natural history generally by his production, in twenty decades, of a *Prodromus of the Zoology of Victoria,* the first part being dated 1878.

While the early explorers Hume and Hovell, and Mitchell, in particular, spoke in general terms of what they first saw, it was the almost immediate explorer-scientists, only twenty years later, exemplified by von Mueller, Blandowski, and McCoy who provided the details on which modern deductions can be based to reduce future impacts to an absolute minimum.

SURVEYING AND LAND ALIENATION

Among the first needs in the settlement of a new country is a reliable map of its extent, configuration, and resources. Settlement in the territory now known

as Victoria commenced with sporadic visits by whalers and sealers in the early 1800s. In 1803 an attempt to establish a permanent settlement near Port Phillip Bay was soon abandoned. However, information gained by exploring parties from Sydney led by Hume and Hovell (1824) and Mitchell (1836) were the first steps in obtaining a picture of the territory, hitherto restricted to coastal charts by the navigators Flinders and Grant.

The knowledge that extensive natural pastures existed south of the Murray River led to a rush in the late 1830s of pastoralists from Van Diemen's Land and the settled districts of New South Wales. The main impact of settlement on the natural features of the Port Phillip District was at first on the region west of Port Phillip Bay where many thousands of hectares were immediately available for grazing sheep and cattle. These and similar areas in the north-east were soon occupied, at first without any official definition of boundaries between occupiers.

The establishment of a Survey Branch at Port Phillip in 1837 and the appointment of Commissioners of Crown Lands led to the fixing of pastoral boundaries and some attempt at preparation of topographic maps. However, a reasonably accurate and complete picture of what Victoria looked like at the time of first settlement is difficult to obtain. The limited resources of competent staff and accurate instruments at the disposal of the Surveyor in Charge, Robert Hoddle, and of his successors, and other demands such as for subdivisions of town and country lands for title purposes, meant that progress towards complete topographic maps was slow. The position was not much improved by the employment of " contract surveyors " and the first general map of Victoria was not produced until 1851. To a scale of eight miles to one inch, it was primarily a topographic map. It gave very little information of the north-west and Gippsland areas but elsewhere depicted many of the streams, lakes, ranges, etc., with a general description of the country. Although many unconnected maps of various districts were compiled as land settlement proceeded, the next map of the Colony was not published until 1876.

It is likely that the early pastoral occupation, which extended only in the natural savannah type of country and did not involve clearing of timber except for fencing and homestead buildings, had little effect on the environment. There was some demand for agricultural land, which was generally met by subdivision of the rich alluvial areas and sale by auction. However, the predominant pastoral use continued until the rapid increase in population after the gold discoveries in 1851 led to radical changes in the administration and disposal of the Crown lands of the new Colony of Victoria. Apart from changes in the environment due to the goldmining industry itself (which besides the impact of alluvial mining on watercourses required large quantities of timber for deep lead mining), there was rapid conversion of many of the pastoral areas by subdivision and sale, mainly by auction up to 1860, and under later legislation by selection of areas up to 130 hectares.

By 1884 when the land laws of Victoria became due for review by Parliament, settlement had occurred on most of the easily accessible and productive areas, and in introducing a new Land Bill the Minister of Lands (Hon. A. L. Tucker, M.L.A.) stated that earlier legislation had by the end of 1880 " brought about the alienation of almost all the agricultural land in the Colony. After that date selection began to change to a very great extent; that is to say, that instead of selectors taking up agricultural land they began to take up grazing land of the 2nd, 3rd, 4th, or 5th quality of soil and not adapted to agriculture at all. They also began to take up small patches of land here and there following the course of the valleys ".

It appears that from this period, encouraged by the provisions of the 1884 Land Act and later amendments, large scale settlement spread into the timbered and hilly regions of Victoria and into the Mallee. The 1884 Act did exempt from

alienation any land classed as auriferous, or as swamp land, or reserved for State forests, timber, or water supply purposes. However, there was provision for the cutting of timber and for timber reserves denuded of timber to be made available for selection.

In 1893, legislation was passed to provide for village communities, homestead associations, and labour colonies, and the Minister (Hon. J. McIntyre, M.L.A.) referred to earlier policies of the Lands, Mines, and Forests Departments of restraining settlement with the result that settlement on the remaining Crown lands " had nearly stopped ". The legislation was designed to relieve the problem of the unemployed (due to a financial recession at the time) and also to provide opportunities for persons to obtain areas of up to 8 hectares in " village communities ", or to form associations to work blocks of up to 800 hectares, or to be employed on " labour colonies " which were to comprise areas of up to 600 hectares. The Minister stated that the land required for the scheme could be found from the area of about 10.5 million hectares which still remained as Crown land, excluding reserves of all kinds. The " most eligible areas as selected by officers of the Lands Department " comprised about 60,000 hectares in practically every county in Victoria. He quoted the counties of Buln Buln (15,000 hectares) and Evelyn (3,000 hectares) as counties within a reasonable distance of Melbourne. Both these counties are still two of the most heavily timbered counties of the State, and a report on the operation of the legislation in 1894 refers to progress on several areas and the need to clear timber. It appears that this scheme led to considerable disturbance of the environment in the Dandenong Ranges. For example, in the first year 1,200 hectares of " very heavily timbered " land at Monbulk (Dandenong Forest) were made available for village community purposes.

Later in 1893 an Act was passed to revoke a number of permanent reservations for water supply, State forest, and other purposes, to enable the land to be used for settlement. This is further evidence of the inroads of settlement into heavily timbered areas—one group of reservations mentioned in the Act contained 4,800 hectares of State forest in the Wombat–Trentham–Blackwood region. Swamp areas were also included in this scheme, but the greatest impact of settlement on swamp lands occurred as a result of the 1884 Act which, although it prohibited alienation of such areas, did provide for many swamps, including Koo-wee-rup, to be drained and reclaimed by the Government and leased for a term of years. Ultimately the right to the freehold was given to leaseholders.

According to reports presented to Parliament a total of 62,408 hectares in 84 separate localities, mainly in timbered and mountainous areas, was made available for village settlement in the 1890s.

Homestead associations proved unsuccessful and were soon abandoned and only one labour colony (at Leongatha) was established. Eventually about 2,550 village settlement holdings matured to freehold amounting to about 22,000 hectares. Under other provisions of the Land Act selections of Crown land, generally in the poorer quality timbered areas, amounted to about 3 million hectares between 1885 and 1900.

Almost simultaneously with the development of timbered and swamp areas during the last decades of the century, settlement began to absorb the suitable portions of the Mallee, a region comprising some 4.7 million hectares which had suffered from unrestricted grazing under pastoral occupation. The rabbit plague had caused a fence to be erected along the region's southern border to contain this pest.

Many areas which were absorbed in settlement schemes during this period, particularly in timbered regions, proved to be unsuitable and after being cleared either wholly or partly were allowed to revert to their natural condition and were restored to forest reserves. However, the position in 1975 is that there are still about 9 million hectares of Crown land remaining in Victoria. Present policies

in regard to land conservation will ensure that very little of these areas will be alienated and that the preservation of the natural environment will be a predominating factor in the future use of Crown land.

WATER AND EARLY SETTLEMENT

Early settlement in Victoria, as in other parts of Australia, was greatly affected by the inadequacy and unreliability of natural water resources, and it soon became evident that water conservation would have to be a dominant feature in agricultural and even in pastoral development.

The salient features of Victoria's hydrology were unknown at the time of early settlement, but they explain why water supply development, though difficult, had to be rapid. These hydrological features which are now recognisable in retrospect are basic to understanding the early attempts to secure a reliable water supply.

Although Victoria's average rainfall is 625 mm per year, its water resources are now known to be anything but uniform or average. More than one third of the country in the north and west receives less than 500 mm of rainfall annually. Another 26 per cent, which receives more than 750 mm a year, is mountainous country not suited to agriculture. Isolated parts of the State in mountains near the coast receive as much as 2,000 mm of rain annually.

Victoria's surface flows are generally oriented north and south by the presence of the broadly east-west aligned Great Dividing range, the mountains of which attract most of the precipitation and in which the major stream flows originate. Rivers flowing north from the Divide join the Murray River, and on the other side of the ranges stream flow is generally south to the coast.

The variation of annual stream flows is considerable and many smaller streams in the north and west regularly cease to flow each summer. The Mallee area of the extreme north-west has no surface streams and underground water is considerably saline. High salinity also limits the usefulness of surface streams in the south-west. Since the early hardships of settlement, the configuration of Victoria's water resources situation has encouraged works of water conservation and transportation. Even today reliance must still be placed on rainwater tanks and on bores of varying salinity where natural or engineered supplies are not available.

At the time of settlement there were few agencies with power to carry out water supply works and there was no special legislation to encourage the development of water resources. Practically nothing had been expended on water supply works outside the metropolitan area.

However, as far back as 1860, some enterprising landowners were irrigating on a small scale in various parts of the State, and far-sighted people were advocating storages on streams to conserve winter flows for summer use and extensive systems of channels to supply water to the dry plains between the rivers. Within a few years, the Government began works which were quite extensive in their day to bring water from considerable distances to the port of Geelong, to the populous goldfields of Castlemaine and Sandhurst (now Bendigo), and other areas under the provisions of the *Waterworks Act* 1865.

In the 1870s a private company—the Grand Victorian North-western Canal Company—proposed to build a large canal from the Goulburn River at Murchison to traverse northern Victoria westerly for more than 320 kilometres before turning southward to the sea. It was intended to benefit 6 million hectares in northern Victoria by providing irrigation in summer, drainage in winter, and transportation of the resulting produce. Nothing came of the scheme, but it is interesting to note that the present course of the main irrigation channel that leads westerly from the Goulburn River into the Mallee matches, as far as it goes, quite closely the route proposed by the company for its main canal.

Legislation to make land available brought many smaller settlers into the northern plains during these years. At first, between 1870 and 1875 everything went well. Rains were copious and seasons were good. Then came the drought between 1877 and 1881 with its very great stock losses. This led to the first big step by the Government—the appointment of Messrs Gordon and Black, an engineer and a surveyor, to report upon the water supply and irrigation of the northern plains, because it was now seen that those areas could not be successfully occupied without artificial means of water supply and irrigation.

Their reports led to the Water Conservation Acts of 1881 and 1883, probably the first Acts in Australia to enable local initiatives to provide water conservation and rural water supply. The former Act allowed locally elected Waterworks Trusts to be set up. They were to be financed by government loans to construct and operate waterworks for general water supply.

The legislation soon became effective. In 1882, a number of trusts was constituted and the Echuca and Waranga Shires came together to approve a scheme for supplying water to a large area from the Goulburn River. This led to the establishment that year of the United Echuca and Waranga Waterworks Trust, one of the first irrigation schemes. The first Waterworks Trust was the Loddon United, constituted on 3 July 1882 to supply water for domestic and stock use only. The United Echuca and Waranga Waterworks Trust was constituted on 11 October 1882. Its main purpose was to provide ample water for domestic and stock use over 1,450 square kilometres with some surplus water for irrigation. Preliminary works were immediately put in hand and, as a temporary measure, a pumping plant was installed on the river to lift water into the channel system pending the construction of a diversion weir.

The Council of the Shire of Wimmera obtained government approval in August 1885 for a loan to commence the construction of the Wartook Reservoir in the Grampians which was later taken over as its main storage by the Western Wimmera Irrigation Trust.

The first Victorian Act specifically concerned with irrigation was the Water Conservation Act of 1883, which provided for the setting up of Irrigation Trusts. However, under this Act, Irrigation Trusts could raise capital only by private borrowing, and it was not until an amending Act of 1885 provided for the granting of government loans to Irrigation Trusts that the formation of Trusts really proceeded.

Royal Commission on irrigation

The whole position, however, in regard to water supply was still far from satisfactory and, in 1884, one of the strongest advocates of irrigation, Alfred Deakin, later to become Australia's second Prime Minister, was appointed Chairman of a Royal Commission on Water Supply. Deakin made a very close study of irrigation in various parts of the world and produced monumental reports dealing with legal, engineering, and agricultural problems associated with irrigation in America, India, Egypt, and Italy. His Commission made very important recommendations concerning the development of irrigation in Victoria. He called special attention to the question of water rights, and to the legal difficulties that had so greatly handicapped and retarded the full utilisation of American water resources. He compared the water laws of the various western States of America, and stressed the marked advantage enjoyed by the State of Colorado whose constitution embodied the provision that "all streams within its boundaries were declared to be public property".

As a direct result of the recommendations of the Deakin Royal Commission, the Victorian Parliament passed legislation in 1886 to establish water supply and irrigation on lines subsequently found to be sound. The outstanding feature of this Irrigation Act was its abolition of riparian rights and its effective nationalisation of all surface waters. By this provision, then well ahead of its

time, Victoria has been spared the costly litigation that handicapped early water supply development in many other parts of the world.

The legislation also provided for elected Trusts to construct local irrigation works with money advanced by the Government, which was also to construct national storages and headworks. It was intended that charges for water from these headworks would cover interest on their cost.

Although the 1886 Act prevented the establishment of any riparian rights after the passage of the Act, it did not define the existing riparian rights. No legislative action, however, was taken in regard to either this problem or the Trusts until 1905. By the Water Act of that year, the common law principles relating to riparian rights were fundamentally modified and the respective rights of the Crown and private persons were clearly defined. A vital provision was that, where any stream or lake forms the boundary or part of the boundary of an allotment of land, the bed and banks thereof shall be deemed to have remained the property of the Crown and not to have passed with the land so alienated. Since 1905, riparian rights in Victoria have been clearly defined and limited by statute.

Mildura irrigation settlement

While in the United States in 1885, Deakin met George and W. B. Chaffey—two young Canadian brothers who had established successful irrigation settlements in California. He was more impressed by what they had achieved than by anything else he saw in North America and invited George Chaffey and later his brother to investigate the possibilities of similar enterprises in Victoria. The Chaffeys saw in the remote, semi-arid north-western corner of Victoria, bordered by the Murray River, the possibility of a great irrigation settlement. The Victorian Government and the Chaffeys entered into an agreement, and after considerable political difficulties, the Mildura project went ahead. The Chaffey irrigation works there were eventually taken over and have since been operated by the First Mildura Irrigation Trust, a locally elected authority set up under special legislation in 1895.

Local Irrigation Trusts

Many local Irrigation Trusts were set up in these years, and work began in 1887 on the Laanecoorie Weir, the first of the national works which was to provide a storage of 14,000 acre feet on the Loddon, and a masonry diversion weir on the Goulburn near Murchison, from which a large channel of 1,700 cusecs capacity was constructed by the Government to take water to the extensive districts being reticulated by the Rodney Irrigation Trust and the United Echuca and Waranga Waterworks Trust.

By 1905 almost ninety Irrigation and Waterworks Trusts were operating in Victoria. They had been constructed and administered by locally elected residents. Nevertheless the system of local management failed. The reasons for this failure were fourfold: first, there was insufficient conservation of water together with an abundance of channels without enough water to fill them in times of need; second, control of the sources of supply was divided; third, there was a real ignorance of irrigation; and, fourth, local management was unable to impose charges that would compel the proper utilisation of the water by the irrigators.

Irrigation under the Trusts had not been successful. The landholders, who mostly held large areas, could not be termed irrigators and many of them did not want to be irrigators. Many of the Trusts had attempted to spread channels over very large areas, intending to supply relatively small quantities of irrigation water for portions only of large land holdings. When seasons were bad there was insufficient water to do any good. This latter difficulty had been foreseen to some extent by the Government which had provided certain free headworks,

but until 1905 very little had been achieved with irrigation beyond a capital liability on State water supply undertakings of almost $12m.

However, the very failure of the Irrigation Trusts led to the establishment of a new type of public authority which could plan the use of water resources and manage irrigation and water supply for the whole State—the State Rivers and Water Supply Commission.

SOILS

Victoria's settlers had to contend with diverse soils developed under a variety of weather conditions, rock type, topography, and age of land surface. Their use of soils may be considered under the headings of grazing, cropping, timber getting, and water supply. Many other activities were affected to varying degrees by soils and one recurring problem is the unprecedented cracking of masonry structures in many districts, caused by seasonal movement of clays.

Except in occasional areas, Victoria's soils in the virgin state were deficient in the major plant nutrients—phosphorus and nitrogen. In general the supply of other nutrients was low in the humid mountainous areas with leached acidic soils of the podsolic kind, but increased towards the drier north and west. The physical features of many soils brought problems not previously faced by Europeans, particularly in the sub-humid parts of the State receiving an average annual rainfall of about 375 mm to 750 mm.

Effects on rural activities

Grazing

Initial settlement was encouraged by the abundance of natural grasslands ready made for sheep and cattle on the basaltic plains which stretch from Melbourne almost to the South Australian border. Here the dominant soils consist of deep grey brown clays with only a discontinuous veneer of grey loamy topsoil. The clays swell and shrink markedly on wetting and drying, producing an uneven surface known as "gilgai"—an Aboriginal term. Large cracks open up in summer causing the drying out of subsoils. By contrast the cracks close up tightly in winter and the dense clays become virtually impermeable, leading to waterlogging. These difficult physical conditions favoured the natural establishment of grasses rather than trees.

On the leached acidic soils in the well watered parts of the State, the woody understorey to the forests was of little grazing value. Notable exceptions were the high plains above the tree line at approximately 1,220 metres where natural grasslands occur on dark friable soils of high organic matter content, known as "alpine humus soils". These grassy plains were settled from the Monaro region of New South Wales.

On the less leached soils of the sub-humid and semi-arid northern and western areas the forests were more open and usually of better grazing value, with a good proportion of grasses in the understorey. Kangaroo grass (*Themeda australis*) provided particularly good feed in the early days.

As clearing of the forests began around Melbourne and the goldmining centres, the lack of nutrients in the soils and heavy grazing pressure allowed only poor cover of native grasses to develop.

Cropping

In the early days of settlement, crops were grown on the open basaltic plains and where timber was cleared from the lower slopes of hilly country close to centres of population.

The main soils on these lower slopes are sodic duplex soils. "Sodic" indicates a relatively high content of sodium in subsoils leading to undesirable physical characteristics. "Duplex" indicates that the upper horizons are loamy, with a

clear break to clay subsoils. The settlers soon learned that these are difficult soils to handle. The upper loamy horizons set hard in summer—so hard that a blow from a mattock can send sparks flying. By contrast, the surfaces turn quite fluid under pressure when wet, and much frustration was caused by bogging of implements and wagons. The lack of ready drainage arises from the dense subsoils with a low content of large pores drained by gravity. There is also the tendency for pores to become blocked by dispersion of clay under the influence of high levels of sodium. These are truly problem soils, not only to handle but also to keep stable, as discussed in the next section.

The originally low levels of nitrogen and phosphorus were soon depleted on the cropped sodic duplex soils, and were not to be replenished until well into the twentieth century when superphosphate and exotic clovers became available. In the 1950s molybdenum was also found to be deficient.

Soils which continued to yield good crops with little fertiliser input were very limited in extent. Notable were brown well-structured clayey soils on young volcanic ash showers scattered around the Western District, for example, around Camperdown, Colac, Terang, and Tower Hill. Red well-structured clayey soils of the " krasnozem " type also resisted nutrient decline relatively well, notably in areas near Ballarat and Trentham, and later on in West Gippsland.

As settlement spread inland the main cropping areas became the northern plains, the Wimmera, and then the Mallee. In these areas the drier climate had produced less leached soils with better nutrient levels. However these soils were also to suffer from declining levels of phosphorus and nitrogen until this was remedied in the twentieth century. On the northern plains the predominant red calcareous duplex soils (" red brown earths ") were difficult to work, being hard setting in summer and poorly drained in winter. The main soils cropped in the Wimmera—grey calcareous clays with well-structured surfaces—were also difficult to handle, being particularly boggy when wet. The sandy and loamy calcareous soils of the Mallee were easier to work, but yields were severely limited by the dry climate.

Timber getting

After early exploitation of magnificent mature timber in the moderate to high rainfall parts of Victoria, supplies of good quality timber became dependent on areas which allowed good growth rates. These occur in the wetter mountainous regions on soils with good physical characteristics and moderate fertility. Mountain Ash grows rapidly on brown and red gradational soils which have loamy surfaces gradually becoming clay with depth. Profiles are permeable, have high water holding capacities, and deep humus-rich upper layers in which nutrients are in good supply. Soils of the less productive but more widespread Stringybark-Peppermint forests have mainly acidic duplex and yellowish gradational profiles.

Water supply

The soils of the high rainfall areas are conducive to the regular supply of water, being absorptive and sufficiently permeable at depth to allow deep seepage of rainwater and subsequent slow release to streams. In addition the low content of soluble salts in the soils gives rise to waters of good quality. By contrast, streams arising in the drier areas are given to flash floods alternating with periods of low flow, and the waters tend to be brackish, particularly with low flows. The clays of the Western District, and the sodic duplex soils of the hilly country shed heavy rains, and the little deep percolation which does occur brings salts from the soils into the streams. Creeks in the Western District are particularly brackish. Further problems with water supply in the drier areas arose when the settlers built dams to trap surface waters. The sodic nature of the soils promoted dispersion of clays, giving rise to muddy waters, silting up of dams, and failure of dam walls by breaching.

Deterioration of soils

Just before European settlement, Victoria's soils were stable, with rare exceptions mostly caused by the Aboriginals on coastal dunes and beside streams. Crests of the highest dunes in the Big Desert also tended to erode. In many landscapes, particularly those in the drier areas, the stability was deceptive, especially to Europeans used to soils which would withstand considerable pressure without rapid deterioration. The introduction of domestic livestock exerting much greater grazing pressure than the native animals, cultivation, and disturbance of native timber frequently had drastic effects on soil stability, causing erosion by water and wind and salting of soils. The effects were not so serious in the Western District where natural grasslands existed on gentle landscapes. The worst deterioration occurred where forests were removed from areas with less than about 750 mm of annual rainfall.

Water erosion

Erosion by water became particularly severe in the hilly sub-humid areas on ancient marine slates and sandstones with shallow stony soils on the rises and sodic duplex soils on the lower slopes. Surfaces set hard tending to shed water in rainstorms. This, combined with rather open vegetative cover induced by overgrazing and cultivation caused surface detachment of soil particles, producing sheet eroded patches. These hard surfaces are difficult to reclaim and lead to severe loss of productivity.

Where run-off entered channels, gullies formed where surfaces had been disturbed, for example, by cultivation furrows, rabbit burrows, or tracks of various kinds. The sodic subsoil clays disperse and are washed away. Once a free face or "gully head" is formed, it moves upslope following rains by various mechanisms including waterfall action, blockfall, and sapping. Sapping occurs where a permeable layer, usually the subsurface horizon, becomes saturated above a slowly permeable layer. Soil oozes out and dribbles down the gully head wall. Subsequently the overlying soil collapses and waterfall action removes the underlying material. Another mechanism in Victoria known as "tunnelling" follows disturbances such as rabbit burrows or removal of tree roots. Dispersed subsoil escapes to the surface following heavy rains forming a tunnel upslope. Eventually the roofs may collapse to form gullies.

Less area is affected by gullies than by sheet erosion, and direct loss of production is therefore smaller. However, gullies interfere with farm operations in that they frequently cannot be crossed by farm machinery or livestock. In addition they lead to silting up of creeks and reservoirs, undermining of roads, and increased flooding.

Wind erosion

Wind erosion following settlement occurred mainly on coastal sand dunes and on overgrazed land in the semi-arid north-west where grazing runs followed the Murray River and occasional creeks. Damage along the coast followed destruction of the native scrub by activities such as burning, grazing, putting in tracks, and trampling by people during recreation. These pressures were to increase with the subsequent growth of population. In the north-west, wind erosion became disastrous early this century after clearing the Mallee scrub for farming, particularly during droughts. This resulted in loss of the more fertile topsoil, especially from the more susceptible dunes.

Soil salting

A problem which arose more insidiously was increased salinity of soils on the lower parts of farms in the sub-humid and semi-arid areas. Damage ranges from slightly lowered production of crops and pastures to total loss of production. Subsequent erosion is promoted, especially gullying in the hilly areas. The basic

cause of salting was changed soil moisture conditions after replacement of the native deep-rooted trees with crops, pastures, and bare fallows. More seepage occurs, carrying salts which were appreciable in the soils. Evaporation at the lower sites causes concentration of salts in the soils, leading to bare saltpans in extreme cases.

Conclusion

The evidence suggests that land-use in the pioneering days was inevitably exploitive. It was not until well into this century that science, technology, affluence, and familiarity with the environment enabled restoration and improvement of Victoria's soils to begin. Fertilisers and improved pasture species have been introduced, overgrazing by rabbits reduced, and activities in forests are being controlled. Restoration is still gathering pace, the job being far from complete. There are still many instances of unstable land-use, and further research is needed for an adequate understanding of processes and control of deterioration.

LANDSCAPE

The landscape can be regarded as consisting of three components : landform, original vegetation, and changes induced by human activity. The first two are initial or primary features ; the third component is a superimposed feature.

Landforms are the result of interaction between rock type, geological history, and climate. An important consequence of this interaction is that particular landforms also develop characteristic soils.

Geomorphically, Victoria consists of an east-west highland spine of mainly Palaeozoic rocks with extensive plains underlain by younger rocks to the north and south. Also in the south are three discrete areas of higher country which, together, form the Southern Uplands. Each region has distinct characteristics which have had an important influence on settlement and which have responded to occupation in different ways.

Fig. 1 shows the areas still unoccupied in 1860 in relation to the main geomorphic regions. The areas of easiest access and more subdued topography were all occupied by this time, those unoccupied being mainly in the high, steep country in the Eastern Highlands, the Otway Ranges, and the South Gippsland Highlands. Also unoccupied were the Big Desert, that part of the far north-west remote from the Murray River (both of which consist mainly of sand dunes with Mallee scrub and heathland), and the intervening plains country.

Changes resulting from settlement

Changes in the landscape due to settlement are either direct or indirect. Direct changes include the removal of native vegetation, its replacement with other forms of vegetation such as pasture, crops, tree plantations, the removal of soil and rock, excavation of various kinds, and the construction of roads, railways, towns, dams, and reservoirs. Indirect changes result from these activities and may or may not have been anticipated. In many cases such activities, although advantageous in the short-term, have produced far-reaching detrimental results.

To illustrate the influence of landform on settlement and the effects of man's activities, mainly in the second half of last century, three contrasting areas are considered. These are : the Midlands, the Western District, and Southern Gippsland.

Midlands

The Midlands are part of the Western Highlands and extend from the Kilmore gap, a saddle in the Great Divide, to the Grampians. They consist of a series of ranges of varying prominence between which are broad north-south corridors of flat to undulating country. Alluvial deposits and volcanic rocks

(basalts and tuffs) are widespread in the corridors, while the ranges consist of resistant Palaeozoic sediments, metamorphic, granitic, and volcanic rocks.

This country is relatively accessible and most of it was occupied by pastoral runs by 1843. Exceptions were the steep, broken country on Ordovician rocks near Daylesford and Bendigo and between Ararat and Stawell. Even this country was occupied before 1850.

This low density pastoral occupation had little effect on the landscape but, with the discovery of gold in 1851, the whole aspect of occupation changed. During the next ten years extensive modification of the landscape occurred as a result of alluvial mining combined with agricultural expansion into adjacent land as the gold started to run out. Agricultural selection continued beyond this period and reached a peak in the 1870s. Deep alluvial and quartz mining which commenced in the later 1850s had its own characteristic effects on the land although these were confined to more limited areas.

The gold worked at the height of the rushes occurred mainly in the colluvial deposits on lower hill slopes, in alluvial terraces along the sides of streams, and in the alluvium forming the valley floors. The colluvial deposits were soon stripped off leaving bare rock and heaps of washed gravel. "Runs" of gold in the terrace deposits were exploited by pits, trenches, and tunnels, the form taken often depending on the distribution of hard bands (cemented wash). The originally smooth terrace form was replaced by irregular excavations and heaps of gravel. In the valley floors large quantities of sediment were worked over, originally to shallow depths but, with the introduction of equipment able to handle greater quantities of material, to greater and greater depths. Some excavations went down to 15 metres or more and eventually large sections of valley floor were washed down to bedrock.

All this activity had far-reaching geomorphic effects. Originally the hill slopes were approaching the graded state; in other words, they tended to have an almost unbroken cover of soil, only the most resistant rocks being exposed. Working of this colluvial cover laid bare the more uneven bedrock surface beneath, which also increased the rate of run-off after rain and aggravated flooding in the valley below. The original form of the alluvial terraces was also destroyed and entire valley floors disrupted, the form of the stream channel and its profile being radically changed.

The recovery and treatment of alluvial and colluvial deposits involved the separation of coarse and fine material. The gravel and coarse sand was dumped near where it was treated producing an irregular, hummocky terrain in place of the original relatively smooth valley floors and sides. The fine material, including an abundance of clay, was carried downstream, particularly during floods, choking the streams and causing the water to flow in a series of anastomosing channels analagous to those of natural braided streams. Thus, by increased stream discharge and by siltation the effects of alluvial mining extended beyond the immediate area of activity, sometimes ruining fertile river flats downstream.

These landscape modifications associated with alluvial diggings were exhibited to a greater or lesser extent on all the Midlands goldfields but were particularly pronounced at Ballarat, Forest Creek, and Bendigo. The serious flooding which followed forced local authorities to re-excavate and straighten the main stream channels, for example, Yarrowee Creek at Ballarat in the early 1870s, Forest Creek at Castlemaine, and Bendigo Creek. These works constituted further geomorphic modification.

From 1853 onwards two other phases of goldmining emerged. These were quartz and deep alluvial mining. On many of the fields large outcrops of quartz were exposed at the surface and formed conspicuous features in the landscape, a notable example being on Monument Hill, Bendigo, but most of these were soon removed. Excavation of exposed auriferous quartz commenced

GEOMORPHOLOGY AND SETTLEMENT

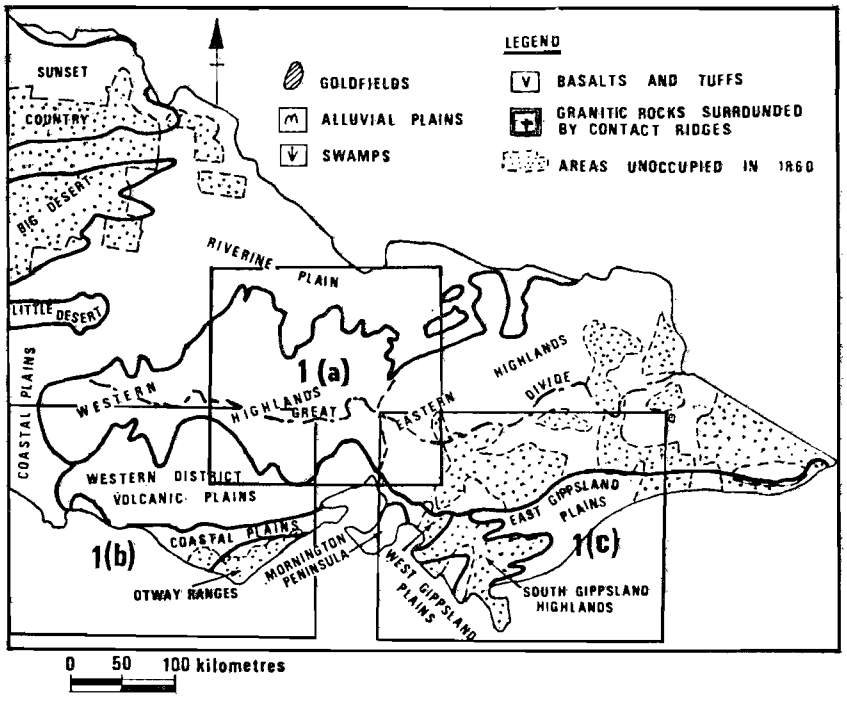


FIGURE 1. Victoria. Areas unoccupied in 1860.

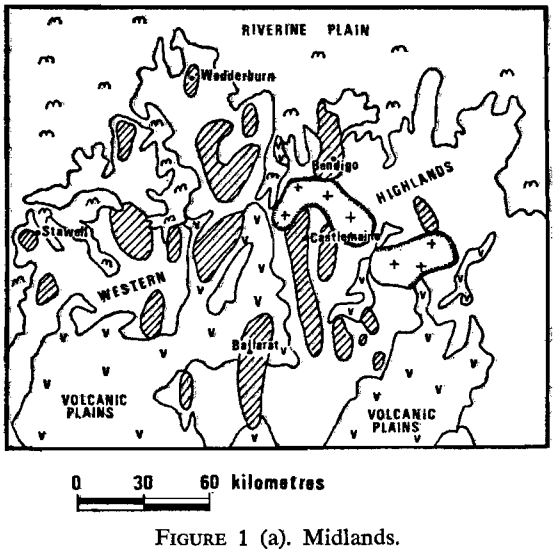


FIGURE 1 (a). Midlands.

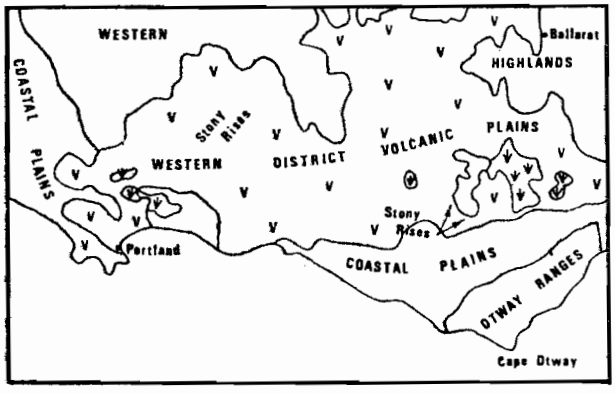


FIGURE 1 (b). Western District.

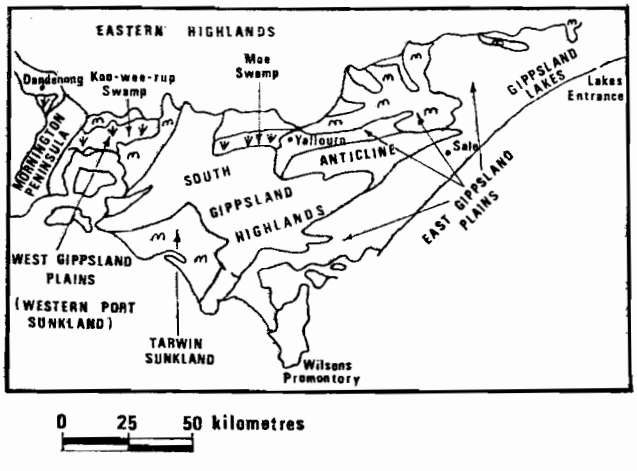


FIGURE 1 (c). Southern Gippsland.

in 1853 and open cuts, trenches, and various types of shafts soon appeared as the reefs were followed below the surface. These activities resulted in pronounced changes in the hill slope profiles, surface continuity being broken by the excavations themselves and also by the dumps of mullock produced. Larger dumps appeared in the 1860s with the advent of deep sinking, and formed prominent features in the landscape on many of the fields. At the same time considerable quantities of ore were crushed and the treated sands poured onto adjacent settling areas. In some cases the sands completely blocked gullies or diverted streams, partly obliterating the original topography. Water supply dams for the mines were also conspicuous features in the landscape in some areas.

Deep alluvial mining also resulted in the production of large dumps of waste and treated material. The distribution of these mines is directly related to the pattern of old stream courses (deep leads) now buried beneath thick alluvial deposits or basalt. The dumps which stand out so prominently on alluvial flats or on basaltic plains or plateaus are generally the result of deep lead mining.

Agricultural expansion occurred most rapidly around the goldfields in the 1860s and 1870s, much of it on inherently unstable soils. Clearing of the land, itself a major change in the landscape, was followed by severe deterioration which is still continuing today. North of the Great Divide, particularly, sheet erosion removed soil from the hill slopes and gully erosion cut deep trenches along stream lines and beside roads. In addition the accelerated erosion produced large quantities of sediment which caused siltation downstream, changing the channel form along natural drainage lines.

Western District

The Western District includes three distinct regions: the volcanic plains, the coastal plains, and the Otway Ranges. The geomorphic character of these regions strongly influenced the order and selection of areas for occupation. The volcanic plains are flat to undulating, their monotony being relieved by numerous eruption centres—mainly scoria cones, maars (circular explosion craters usually occupied by a lake or swamp and surrounded by a low ridge of tuff), and more rarely, basaltic cones. Lakes and swamps are common and sometimes very large, the broad depressions in the plain surface frequently constituting a drainage problem. Another characteristic feature of some areas are the stony rises, which are very young lava flows which preserve their original rubbly surface features and form very rough terrain.

The first permanent settlement was established at Portland in 1834 but during the next three years the country with fertile soils which lie on fine tuff around Colac and Camperdown, was also occupied. Most of the volcanic plains, however, were occupied by 1843, the main exceptions being the stony rises and the swampy areas between Portland and Heywood. By 1850 the whole of the volcanic plain had been occupied.

Agriculture on the plains was predominantly pastoral and has remained so to the present day, except in the areas of particularly fertile soils where dairying and market gardening are concentrated. Potato growing, for example, was well established near Warrnambool in the mid-1850s.

Geomorphically the volcanic plains remain essentially as they were at the time of the first settlement, in marked contrast to the goldfields of the Midlands. Comparatively little clearing was required as much of the country was open grassland or savannah. Minor changes were introduced with the draining of swamps and the symmetry of some of the scoria cones and tuff rings has been broken by quarrying. In some areas, particularly near the stony rises, the surface was cleared of volcanic boulders which were used to build dry stone fences.

The coastal plains of the Western District are of two main types. Between the South Australian border and Warrnambool, but mainly west of Portland,

the plains consist of prominent dune ridges formed along old shorelines representing still-stands in the retreat of the Quaternary sea. Extensive swampy tracts which required draining before they could be utilised occurred behind the dunes. Consequently they were the last areas to be settled in this section of the plains.

East of Warrnambool the coastal plains are underlain by Tertiary limestones, clays, and sands and become progressively more elevated and more deeply dissected. Most of the flatter country in the western half of this section of the plains was occupied before 1850 and the steeper, heavily timbered country towards the Otways was the last to be occupied.

The Otway Ranges also are included in those areas still unoccupied in 1860. The Ranges consist of Mesozoic sandstones and mudstones, the central part being maturely dissected, the flanks, covered by a veneer of gravels, sands and clays, less so. Only limited areas within the ranges and around the flanks have been cleared.

Southern Gippsland

The country south of the Eastern Highlands embraces three distinct regions: the West Gippsland Plains occupying the Western Port Sunkland, the South Gippsland Highlands, and the East Gippsland Plains, also a sunkland. The Tarwin Sunkland is a smaller low-lying area in South Gippsland.

The major geomorphic factor restricting settlement on the West Gippsland Plains was the extensive Koo-wee-rup swamp which covered more than 48,580 hectares. The more accessible, slightly higher country west of the swamp and limited areas on the east side were occupied in the late 1830s. However, the route to the east was extremely difficult and it was not until 1888, when the Great Southern Railway spanned the swamp, that ready access was achieved. Some attempts at draining sections of the swamps were made in the 1870s and 1880s, but the main drainage scheme was not initiated until 1889 and the first blocks allocated in 1893. Draining of the swamp, followed by clearing, removed a major geomorphic bar to settlement.

The South Gippsland Highlands are similar to the Otways except for several large areas of basalt on which deep red soils have formed. Settlement of the steep country did not begin until about 1870–1875 and since then most of the hills have been cleared. The hill slopes are inherently unstable and are liable to landslipping, a feature which was severely aggravated by the removal of the protecting forest.

The East Gippsland Plains consist of extensive alluvial flats and broad river and coastal terraces. The coastal terraces frequently carry conspicuous dune ridges and sand hills. Towards the east the plains are occupied by the extensive Gippsland Lakes system enclosed by sandy beach barriers. Similar barriers in the Corner Inlet area are broken by tidal passes allowing access to ports such as Welshpool and Port Albert.

The area was first penetrated from the north in 1839 and by 1844 all the plain country was occupied. Land access from Melbourne was difficult because of the intervening ranges and swamps. Sea transport was, therefore, important and Port Albert became an important point of access in the 1850s. In 1855 supplies were taken from Port Albert to Lakes Entrance by boat and the first boat entered the lakes through the natural entrance in 1858. Attempts to maintain this entrance by dredging were unsuccessful and a new entrance was opened in 1889 with the assistance of a storm. When the breakthrough occurred, lake levels rose by about 3 metres, and low-lying farms were temporarily inundated.

The opening of the new entrance re-introduced tidal conditions to part of the Gippsland Lakes system and was accompanied by an influx of salt water which has affected the lake shore vegetation and contributed to erosion.

Sedimentation patterns have also changed, particularly around the entrance itself, and the former entrance has been obliterated by sand dunes.

Another effect of occupation is the severe river bank erosion, particularly along the Avon River. In the 1860s the Avon was a narrow stream with steep forested banks. Since then, due to clearing, the river has become a broad expanse of gravel and sand traversed by a network of braided channels. At least 1,215 hectares of fertile river flats have been lost as a result. In about 1867 the Avon was navigable to Redbank, 13 kilometres upstream from its mouth, but the channel soon became silted up and the landing place abandoned.

Other geomorphic modifications have been brought about by the grading of land and the construction of supply channels and drains associated with irrigation. In Gippsland this process commenced in 1919 with the construction of Glenmaggie Dam and now involves most of the alluvial plains between the Latrobe and Avon Rivers.

PLANT COMMUNITIES

The present plant communities of Victoria have almost all been influenced by the effects of human settlement. Since the arrival of the European settlers some Victorian plant communities have become virtually extinct, and many more drastically altered in species composition. The effects of human settlement since the early nineteenth century may be summarised under four headings:

(1) The clearing of forest and scrub for settlement, crops, and pasture;
(2) the introduction of domestic grazing animals;
(3) the deliberate, and accidental, introduction of new plant species; and
(4) the increased frequency of fires in some areas.

These effects have varied in degree: areas such as the Big Desert and parts of far eastern Gippsland have remained almost unaltered, while areas such as the Western District and Wimmera plains have undergone great changes. These latter two areas now carry a flora consisting largely of naturalised species. Other areas, cleared initially for timber, or cleared during the gold rush era, have now secondarily regrown (for example, Wombat Forest, mentioned on page 30).

In attempting to pinpoint the effects of settlement, comparative data is needed. Fortunately, the notebooks and sketch maps of the early explorers contain a good deal of this material. For example, the information in notebooks of Batman's party shows that before settlement Melbourne had a large area of Swamp Paperbark (*Melaleuca ericifolia*) vegetation at the mouth of the Yarra River and along the flood plains of its tributaries (Moonee Ponds Creek, Maribyrnong River). None of this vegetation is left in that area today.

Batman's party, and other early visitors to Port Phillip Bay, made much of the lightly treed and treeless grassy plains to the north and west of both Melbourne and Geelong. These plains carried a rich and diverse flora, with Kangaroo grass (*Themeda australis*) and Wallaby grasses (*Danthonia* spp.) as the most frequent components. These plains, developed on the volcanic soils derived from basalt and extending through the Western District, became the focal point for settlement by the early pastoralists.

Destruction of the native plant communities in this area was achieved in two ways: first, through deliberate introduction of pasture grasses from Europe, and second, through the different effect sheep grazing had on the grasslands as compared to the native kangaroo and wallaby populations.

The extreme palatability and nutritional qualities of Kangaroo grass made this species a prime target for grazing in the early days of settlement on these lush plains. Because of its upright mode of growth, Kangaroo grass is easily overgrazed. This contrasts with tufted grasses, such as Wallaby grass, which can rapidly re-grow after grazing. Although some native grasses can stand sheep grazing pressure, the more vigorous introduced grasses tended to replace Kangaroo grass in heavily grazed pasture. The rapid spread of pastoralists

between 1835 and 1850 meant elimination of some species of native plants, and a great change in the character of the grasslands. Kangaroos and wallabies when grazing tend to select different species from sheep, which meant that sheep grazing together with kangaroo grazing allowed a slow change in the flora. Reduction of kangaroo populations by the earlier settlers further tended to hasten the flora change under the sole influence of sheep grazing.

Paperbark swamps (with *Melaleuca ericifolia* as the chief constituent), although not so altered in character as the basaltic grasslands, are nevertheless now reduced to a small fraction of the area they once occupied. The early expansion of Melbourne along the Yarra River and its tributaries was chiefly responsible for the decline of these swamps, which are no longer found in this area.

Perhaps the greatest area of Swamp Paperbark to be cleared was the area known as the "Dalmore" swamp, in the south-east of Cranbourne Shire. The land was leased, and extensive drainage work begun in the last twenty years of the nineteenth century. This large area of swamp is now pasture for cattle (mainly introduced grasses) or else given to crop production (e.g., potatoes). Remnants of the former extensive plant communities are now restricted to drain sides, and isolated undrained spots in paddocks. An area such as this (now known as the Koo-wee-rup swamp) has obviously been successfully utilised, even though drastically altered.

The south Gippsland hills, in contrast, are an example of an area now very different in vegetation, but not particularly useful land. The former forest has been eliminated, and replaced by rather poor pasture, of which the native bracken (*Pteridium esculentum*) is a major constituent, together with various introduced species and some remnants of the former forest flora.

Perhaps the area in which the effects of settlement are most obvious to the eye is the Wimmera wheat belt. This area is included in Major Thomas Mitchell's *Australia Felix* and was one settled quite early in the history of the Port Phillip District. Mitchell tells of extensive grassy plains, with scattered trees, and patches of more extensive forest. This former open forest of Buloke (*Casuarina luehmannii*) and Grey Box (*Eucalyptus microcarpa*) has now almost vanished, and is only abundant along roadside edges. Like the basaltic grasslands, native grasses have either been depleted, or else the proportions of species in communities have changed markedly. This is a continuing process.

Another vegetation type that has been reduced to a marked degree since the arrival of European settlers is coastal heathland. This has the distinction of being possibly the first vegetation to be affected by man in the Port Phillip District—by the temporary colonies of sealers which settled on the Bass Strait islands, Wilsons Promontory, Phillip Island, and numerous other havens along the western coast of the Colony. Such effect as they had may be viewed as temporary, in that the bush would rapidly regenerate once the sealers had left—but there was always the likelihood of introducing a new species to the flora. By such temporary colonies, European man has spread his "weeds" to places as remote as the islands of the Southern Ocean, including Macquarie Island. Some colonies were more than temporary, however, as a party led by Captain Weatherall records in 1826. His party found a group of sealers who had cleared 0.8 hectares on Phillip Island and were growing crops of wheat, maize, and sundry vegetables. Although the party were evidently glad to be returned to Port Jackson, the effect of crop weeds on that patch of coastal scrub would have long outlasted them.

The initial establishment of Melbourne's suburbs first at St Kilda, and later at Brighton, has led to the most dramatic effect of man on coastal heathland in central southern Victoria—in Melbourne's south-eastern suburbs. The map on page 28 (Fig. 2) shows the former extent of heathland, and its progressive reduction to present levels. This denudation of the vegetation contrasts the

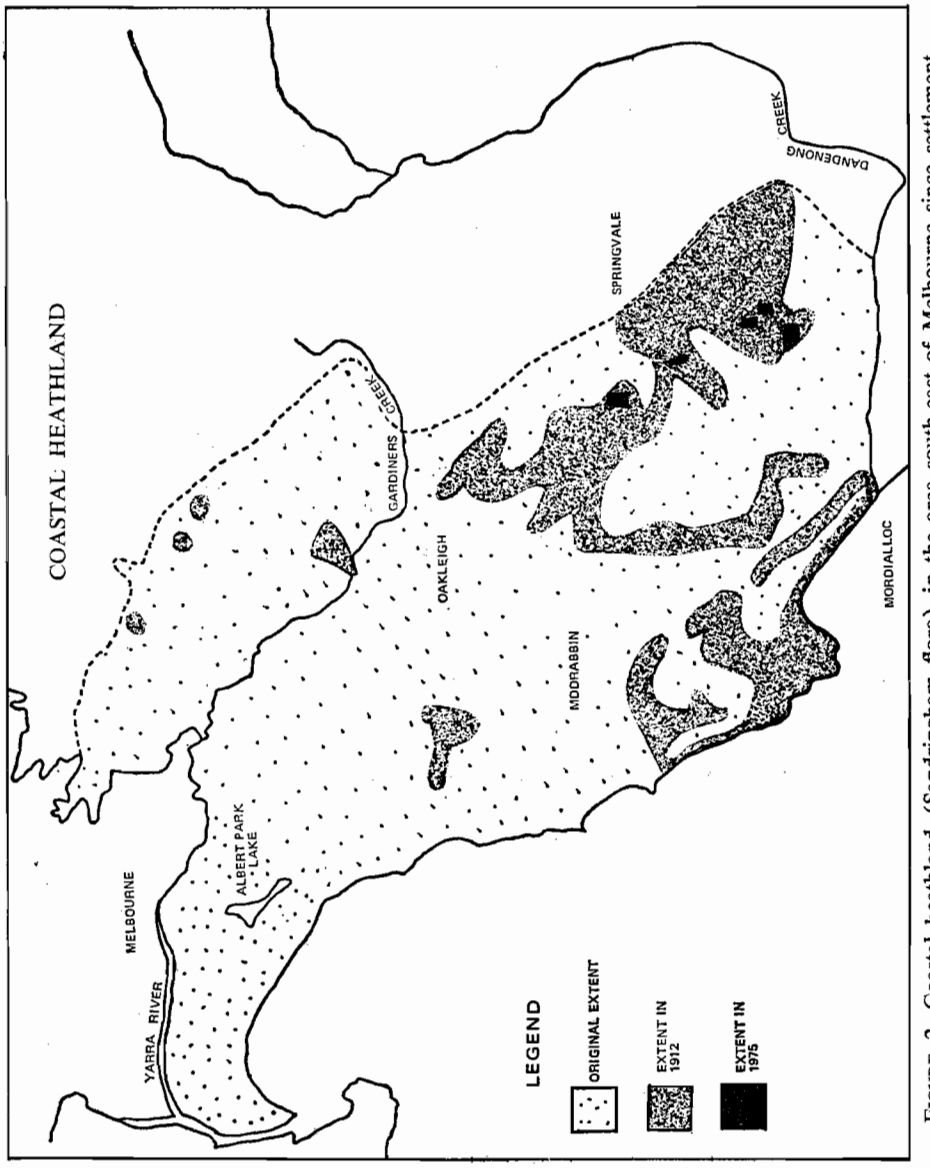


FIGURE 2. Coastal heathland (Sandringham flora) in the area south-east of Melbourne since settlement.

pronounced effect that recent settlement has had on plant communities with the earlier, more moderate alteration of community composition. On the one hand, species are being forced to extinction because of a reduction in available habitat, and on the other hand, the habitat may be available, but an alteration in the biotic conditions may eventually render the species extinct.

Emerging from this is the most lasting effect man has had, and will continue to have, on native plant communities—the introduction of new species. An examination of the flora of Victoria shows that approximately 30 per cent of recorded species are regarded as introduced. Some of these will have been accidental introductions—weed seeds brought in with crop seeds, seeds caught in animal products, and so on. However, some species have been deliberately introduced, as shown in the following two examples.

Furze (*Ulex europaeus*) was introduced as a hedgerow plant, and because of its probable value in enriching poor land. By 1894, it was proclaimed as a noxious weed in Eltham Shire, and by 1908 it was so proclaimed for the whole State. It is quite common today—rapidly colonising spoil heaps, waste ground, and neglected pasture. It rarely, however, becomes invasive of native vegetation that is in a healthy situation.

Perhaps the best example of a species that was introduced for helpful purposes in the early years of settlement and has had a marked effect on native vegetation is the Blackberry (*Rubus fruticosus* agg.). This species was introduced for its fruits and excellent hedging and erosion preventing attributes. The precise date of introduction is not known, but it is recorded as growing in the Melbourne Botanical Gardens in 1858.

At the present time, Blackberry occurs along numerous stream sides in the highlands, where it provides severe competition for the native flora. In some areas it has spread from the stream sides out to the surrounding forest. In such situations the richness of the native flora is severely depleted. Like Furze, it will also colonise neglected pasture.

Both Furze and Blackberry are found in sites characterised by some form of disturbance—either natural or induced by man. Their ability to colonise rapidly disturbed sites is in marked contrast to many native plants, which are not adapted to colonise such sites. Examples of native plants which do colonise disturbed sites include native Violet (*Viola hederacea*), Kidney weed (*Dichondra repens*), Bidgee-widgee (*Acaena anserinifolia*), Smooth nettle (*Australina mulleri*), and Scrub nettle (*Urtica incisa*). All of these species are found in their normal distribution in sites of natural disturbances, and so are well adapted to colonise footpaths, roadsides, etc.

The very few native species that have the potential to become weeds perhaps indicate the differences between the effect of man on the vegetation and plant communities of Australia and those of Europe. In the case of Europe, man has been interacting with native vegetation for thousands of years in a slow, but persistent fashion. The result is that the flora of Europe has many species whose habitat is usually associated with man and his crops, and which are not found in plant communities regarded as natural, or even semi-natural.

This contrasts very much with Australia, where the plants and their communities have evolved primarily with the climate and soils, and only in the last 200 years has man interacted with them. The result has been the situations described earlier—a general reduction in the area occupied by exclusively native flora, and an expansion of many introduced plants to almost all existing native plant communities.

TREES AND FORESTS

When European colonists arrived in the Port Phillip District the vegetation over most of the region consisted of open eucalypt forest in which tall perennials such as Kangaroo grass were dominant. There were some small areas of closed

rain forest of Lilly Pilly, Beech, and Sassafras in the high rainfall areas of the Otways and Gippsland where drought and fire were extremely rare. The general effect of decreasing rainfall with increasing distance from the coast was for the tall open forests in the south to grade into low open forests and woodlands farther inland and for this to grade into eucalypt, mallee, and saltbush. The outstanding exception to this pattern was the River Red Gum forests along the major rivers which thrived on floodwater rather than rain.

Early explorers travelling westward in Gippsland towards Western Port and Port Phillip encountered dense scrub on the flat swampy land about Koo-wee-rup. They also recorded dense forest with thick undergrowth in the South Gippsland hills. In the north and over much of the west of Victoria the grass beneath the open forest was described as growing in large tussocks, standing from about one to twenty metres apart. It bore no resemblance to a sward, and when driven over in a dogcart, "a succession of bumps was experienced from its lumpy way of growing". Large areas in the north were covered, in addition to a little grass, with saltbush and pigface. In some places such as the Terricks the saltbush grew to a height of seven metres. In other places a smaller variety of this plant grew so close as to eliminate the grass.

There is little doubt that the early colonists were appalled by the forest environment with its lack of game and food, drab colours, fire, drought, and timber which at first appeared useless except as fuel. Their first requirement was to grow enough food for survival and produce for trade. They quickly discovered that soils were generally poor and that the trees and other vegetation provided neither food nor produce for export. The Colony soon became heavily dependent on grazing, particularly by sheep, which thrived on the native pastures. Since the natural clearings and woodlands could be grazed with a minimum of effect they were the most favoured.

The grazing runs held by the squatters in this era were large, averaging more than 16,000 hectares, and the sheep were herded with a minimum of assistance of fences. At first there was little need for timber other than to build the few homesteads, so the impact on the appearance of the forests was then small. However, grazing did produce significant changes in the ground flora. As the tussocks of grass were grazed down they stooled out, seed was trampled into the soil around them, and grew to produce a more or less continuous sward of grass. Pigface and saltbush suffered from grazing and in many areas completely disappeared.

The mining era of the 1850s and 1860s produced a rapid increase in population and some quite marked changes in forests, but only over very limited areas. The miners stripped the vegetation from above the rich alluvial gold deposits and later, when shafts were sunk and boilers were used, they clear-felled the adjacent forests for timber and fuel. Some of the forests cleared in this era later became farm land, while others such as those near Ballarat, Daylesford, Bendigo, and Walhalla, regenerated. Today, these second-growth forests contain much the same species composition as the original forest, but their structure is quite different. For instance, in the Wombat State Forest near Daylesford, many of the stumps of the original forest felled a hundred years ago can still be found and suggest that there were fewer but larger trees per hectare than in the century old regrowth forest.

The major effect of the gold rush era on the forests and vegetation of the State was caused not by mining, but by the increase in population which occurred from that time onwards. At the Census of 1851 Victoria's population was 77,345 not including Aboriginals, but by the 1857 Census it had risen to 408,998 (again excluding Aboriginals). Once the alluvial gold was gone large numbers of people had to find alternative work and attempts were made to settle many of them on the land. This settlement made the greatest impact experienced by the forests in the whole history of Victoria.

Much of the land suitable for settlement was held by squatters and laws were passed which enabled "selectors" to take up land on the squatting leases. As a result, much of the woodland and open forests formerly grazed by wandering herds of sheep and cattle came under more intensive use. The selections were small, and in order to make a living, the selector had to kill the trees by ringbarking or felling to improve the grazing. In fact, regulations required the selector to do a certain amount of clearing before he obtained title to the land.

The effect of this settlement on the Red Gum forests of Gippsland was to eliminate all but some remnants in small timber reserves and along streams and surveyed roads. Along the Murray River a levee was built from Ulupna to Picola to allow farming to extend into forest formerly dependent on flooding.

The low, open forests and woodlands were easily cleared, first by ringbarking to improve grazing, and later by burning the dead trees to allow cultivation for crops. Large areas of Stringybark, Gum Peppermint, Box, and Ironbark forests disappeared in this era, particularly on the red-brown earths and other good soil types.

In other higher rainfall areas, such as the Otways, the impact of settlement was slower, but by 1900 extensive areas made available for selection over previous decades had been partly cleared for farming. This included forests containing Mountain Ash, Blue Gum, Beech, Blackwood, and Satin Box growing in sizes which are unknown anywhere in Victoria today. Mountain Ash with girths over 23 metres at two metres from the ground, others more than 100 metres high, and Blackwood containing 36 cubic metres of timber were recorded by reliable witnesses from the area. A Royal Commission reported on the Otway Forest in 1899 as follows: "The destruction of Mountain Ash and Spotted Gum in some parts is simply appalling. On scores of selections immense numbers of young trees, the growth of the past fifty years which for height and proportion could not be surpassed in the Colony, running as they do without a branch for 120 to 200 feet, have been ringed in a face".

There was a similar pattern of land-use in the Strzelecki Ranges of South Gippsland where large areas of Mountain Ash, Gum, Messmate, and Blackwood forests were cleared for farming. These examples, and others, destroyed enormous quantities of timber, enough, according to one emphatic if exaggerated report in 1899 "to pay the national debt". They also destroyed or irrevocably altered for all time, the native plant communities on the cleared land.

By the end of the nineteenth century, concern was being expressed by many people in the community about the extent to which forests were being cleared, the loss of timber, and the lack of control over the timber industry. As a result of this concern, legislation was enacted in 1907 to place the protection and management of State forests under the control of a forest authority. Since that time the impact of man on the forests has been controlled by legislation which has been strengthened from time to time but otherwise has remained fundamentally unaltered.

In addition to clearing and grazing, man has had a profound effect on some forests and vegetation communities by his use and misuse of fire. Most of the native vegetation communities in Victoria are adapted to a specific frequency of burning, and are considerably altered if the frequency is changed. In some forests, particularly the Mountain Ash forests, accidental and deliberate fires caused by man have increased the frequency with which particular areas were burned. This has eliminated the Mountain Ash in some areas and changed the vegetation to a type dominated by Wattle and, in some instances where fires were very frequent, to bracken and Dogwood. Where man has decreased the frequency of burning by successfully exercising a deliberate policy of excluding fire for long periods, the changes that occurred in the native vegetation generally favoured woody species at the expense of herbs and annuals.

The widespread wildfires which burned over more than 1.2 million hectares of forest in 1939 were caused by man. In addition to the damage done to timber, property, and life, these fires were significant in decreasing the amount of diversity which occurs naturally within the forests. They burned over huge areas in the one season and produced uniform stages of recycling over large areas within each vegetation type.

Another impact of man on the forest was the extraction of timber which increased after the Second World War. As the 1939 wildfires had burned large areas of Mountain Ash, new forests had to be roaded and logged. This development extended into the Alpine Ash forests of the eastern mountains and the mixed species forests of East Gippsland. This shift of industry has now extended its influence throughout practically all Victorian forests.

The community since settlement has gradually come to understand that the presence of people in forests is not always good for the forest. People pollute, create noise, litter, tramp vegetation, compact soil, and tend to destroy the very things they seek to enjoy. These factors have already had a very considerable impact on some forests. In order to minimise the undesirable aspects of this impact, forest land managers over the years have had to upgrade legislation, education, and supervision relating to forest recreation. This upgrading has been motivated as much by recreationists themselves as by the management authorities. In other words, people not only wish to use forests but they have become aware of management problems and are insisting that the forest environment be protected and conserved.

VERTEBRATE FAUNA

In order to document changes in a diverse fauna over a period of 140 years with any sense of adequacy one would need measurements of the abundance or density of each species made at a large number of defined locations at recurring intervals of time. Such an objective is virtually impracticable. Even for the best known species there are no better indications of density than terms like "abundant" or "rather rare". Students can therefore only recognise changes of the most sweeping kind, as when a species disappears completely from a large region where it was once known to be common.

Victoria's early naturalists noticed a change in some elements of the fauna within ten or fifteen years of the founding of Melbourne. Then, as now, deliberate destruction of animals by poison, or by shooting and trapping for commerce, sport, or food was most often blamed. However, the more perceptive observers were already aware that fundamental changes to habitat posed the really irreversible long-term threat.

There is still no way of apportioning responsibility for the decline in Victoria's wildlife among all the new influences which affected it. For most species several factors will each have played a part in increasing mortality (or inhibiting reproduction) to the point when the population could no longer sustain itself. Few species would have been reduced by hunting alone, if the original habitat and food supply had remained intact. Many may have survived in the remaining fragments of their habitat if the rabbit had not followed or if the poison cart had not followed the rabbit. The most useful records refer to birds which consistently attract the most attention from field naturalists.

In 1844 lyrebirds were widespread from the high country of Gippsland "southward through favourable tracts of country to the coast but not further westward than the Plenty Ranges". They were known to breed within 45 or 90 metres of the sea. In 1847 they were on "the river side of the Dandenong Ranges" and in the 1850s "the blacks (make) periodical excursions up into the ranges, . . . and come back laden with tails". In 1890 between twenty and thirty were seen at one time on the ridge from Feathertop between the Ovens River and Snowy Creek, and in 1905 it was still "perhaps the commonest

VICTORIA AT THE TIME OF SETTLEMENT

The early years of settlement encouraged many artists to depict their new surroundings and some of their works are reproduced here to illustrate pages 1–45 of the text.

Fern Tree Gully, Mount Useful, Gippsland. Nicholas Chevalier, *Album of Chromo Lithographs*, Melbourne, circa 186–
La Trobe collection, State Library of Victoria

A bushfire to the north of Mount Moriac at night extending in one unbroken line "full 30 miles". Michael Minter, 1854
La Trobe collection, State Library of Victoria

Overlanders. S. T. Gill,
Victoria Illustrated, Melbourne, 1850–1857
Ministry for Conservation

The Dargo Valley, Gippsland. Nicholas Chevalier, *Album of Chromo Lithographs*, Melbourne, circa 186–
La Trobe collection, State Library of Victoria

Mangrove Creek, Western Port. Dumont d'Urville, *Voyage en tour du Monde*, Paris, 1830–1835
Ministry for Conservation

Brush-tailed rock wallaby. John Gould,
The Mammals of Australia, London, 1845–1863
National Museum of Victoria

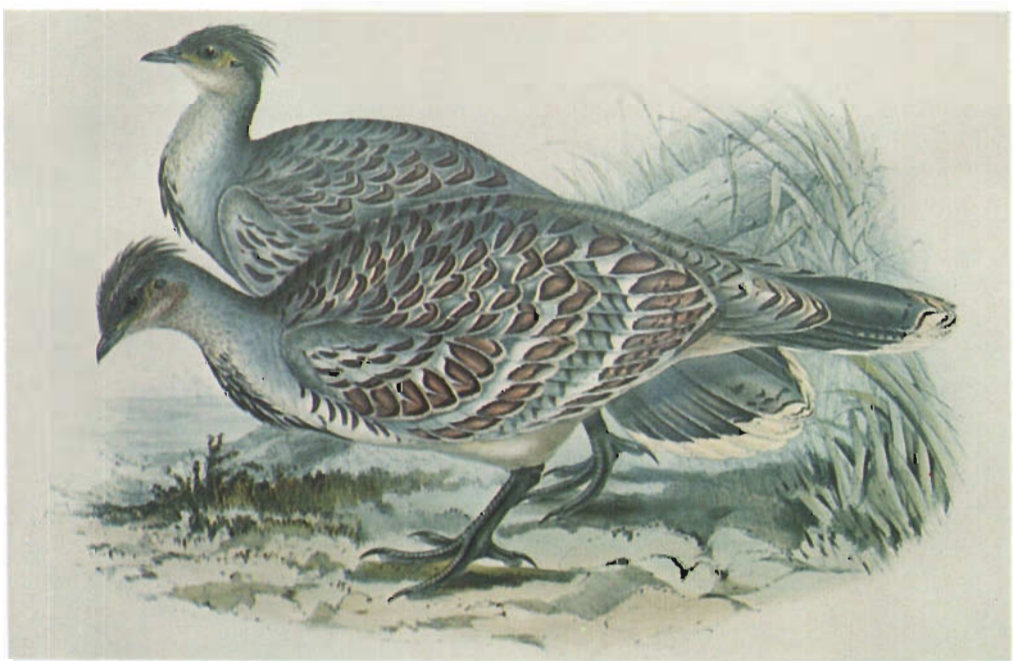
Goulburn River near Shepparton. Eugène von Guérard,
Australian Landscapes, Melbourne, 1862
Ministry for Conservation

Eastern native-cat. John Gould,
The Mammals of Australia, London, 1845–1863
National Museum of Victoria

The Yarra, Studley Park. Nicholas Chevalier,
Album of Chromo Lithographs, Melbourne, circa 186–
La Trobe collection, State Library of Victoria

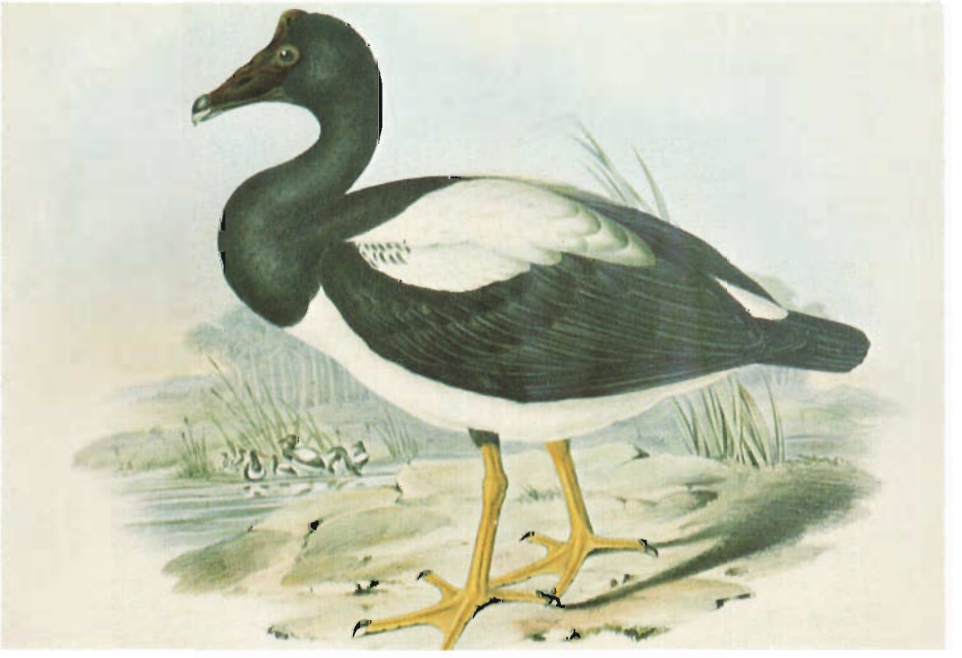
Wentworth River Diggings, Gippsland. Nicholas Chevalier,
Souvenir Views of Melbourne and Victorian Scenery, Melbourne, 1867
Ministry for Conservation

Lowan or Malleefowl. John Gould,
The Birds of Australia, London, 1840–1869
National Museum of Victoria



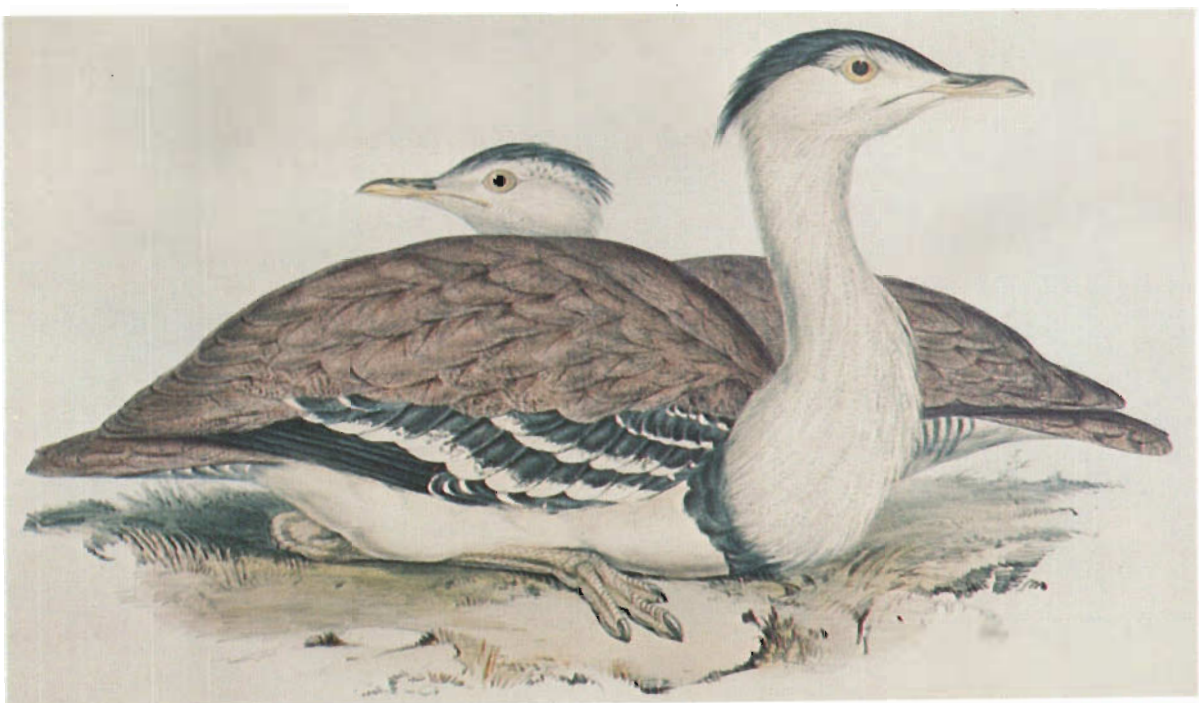
Ballan House in 1851. E. Von Stieglitz
La Trobe collection, State Library of Victoria

Pied goose. John Gould,
The Birds of Australia, London, 1840–1869
National Museum of Victoria



Bustard. John Gould,
The Birds of Australia, London, 1840–1869
National Museum of Victoria

Brolga. John Gould,
The Birds of Australia, London, 1840–1869
National Museum of Victoria



bird " around the headwaters of the Yarra River although by then fears were expressed about its ability to survive the depredations of the introduced fox. In that same year it was claimed " As regards South Gippsland the Lyre-Bird is doomed . . . by the agency of man. In every gully . . . the lovely notes of the Lyre-Bird could be heard . . . (but) patches only of scrubby country are left. These become the temporary home of such of the outcasts as have escaped the gun, the clearing and the fire, till they, in their turn, become felled and burnt, when Lyre-Birds disappear ". Ten years later it was reported from the extreme east of Victoria where, even today, there are few obvious signs of gross habitat change : " (Lyre-Birds) were once very plentiful in this district, but of late years they have become rare. This is put down to the increase of the imported fox ".

Except for one or two very small patches, there are no lyrebirds now west of Lake Tyers on the Gippsland coast, and there seems little prospect anywhere of seeing twenty or thirty at one time. Thus the pattern of the decline appears to be a contraction of range in the south and west due to extreme fragmentation of habitat. It also represents a reduction in density over the residual range due to a combination of hunting (in earlier days), predation by introduced foxes and cats and, possibly, more frequent burning which reduces the forest litter on which lyrebirds depend for food.

Some twenty years after Melbourne was founded a professional hunter wrote " kangaroos appear to be regarded as nuisances in the bush and every means are used to exterminate the race. . . . We scarcely ever now see a kangaroo within thirty miles of Melbourne and they will soon become scarce even in the wilder country ". He estimated that more than 2,000 were shot in two years (probably between Dandenong and Frankston) but added perceptively, " it seems as if they could never be shot out although as the country becomes more peopled their numbers must decrease ".

Unfortunately one excellent record of kangaroo density in the early days omits to give either the date or the place, but in Victoria around 1850 there was " a property of some 60,000 or 80,000 acres on which ten thousand (kangaroos) were killed and skinned annually for six consecutive years, their numbers still remaining very formidable in the locality ". One possible explanation for these figures would be to assume an original population of 40,000 kangaroos on the 32,000 hectares. If the breeding rate were 16 or 18 per cent per annum, an annual cull of 10,000 would still leave about 10,000 kangaroos at the end of six years. Even today there are a few places in Victoria where the density of kangaroos reaches one head to 0.8 hectares, but this density only extends over small areas.

By 1885 French and Best said kangaroos were being ruthlessly destroyed everywhere and considered " the time is probably not far distant when it will be a rarity . . . to see them in their native haunts ". Practically all the lightly wooded grasslands where grey kangaroos flourished are now used for agriculture and although secure numbers survive in open forests they seldom reach very high densities ; lack of grass may keep the numbers down.

A consideration of eight of Victoria's largest birds, all of which sustained a good deal of hunting pressure in earlier times, whether for food, sport, commerce, or pest control, suggests marked differences in the relative change of status.

The Cape Barren Goose may never have been abundant in Victoria. It declined to a critical level at the turn of the century but recovered quickly under protective management. The Pied Goose was once " the common wild-goose in . . . Port Phillip ". By 1920, six birds near Colac were remarkable and nowadays only occasional stragglers from the north are reported in Victoria. The Lowan occurred near Ballarat and between Anakie and Melton until 1879, but six years later not " within hundreds of miles of Melbourne ". It survives in

national parks and wildlife reserves in the Mallee but rabbits still degrade the habitat. The Bustard once ranged as far east as Western Port. In the middle of the nineteenth century it was said "few are met with now in the neighbourhood of Melbourne . . . but they abound on the large sheep stations up country" and "as many as twenty-seven (were seen) feeding together on the wide open country towards Geelong". With other grassland species they suffered from the extensive changes in western Victoria and there have been very few reports in recent years.

When Melbourne was founded, Brolgas were plentiful along the Yarra River. In 1888 "several flocks" were seen in a few hours between Diapur and Dimboola. In 1902 "large numbers of flights" were seen near Swan Hill and "a few flocks" at Echuca, while near Rochester "a large colony" was destroyed by a storm. In 1912 they were very common near Lake Boga "during seeding time" and regarded as "pests of the wheatlands" which led to them being "poisoned wholesale with strychnined wheat". The drainage of wetlands and clearing of swamp margins must also have affected Brolgas adversely and now only a few pairs nest each year near the more sheltered swamps.

Emus were shot as pests, boiled down for oil, and skinned for rugs. Fifty years after settlement they were described as "a noble bird fast becoming extinct", but in fact they have survived reasonably well in the more extensive open forests of eastern and western Victoria. Wedge-tailed Eagles were formerly thought to kill significant numbers of lambs and have only recently been protected by law. Their numbers in the Mallee were greatly reduced by 1888. Private bounties were paid for them in 1900 and they were said to be "easily poisoned". Even in the mid-1960s it was not uncommon to see eight or ten "kills" displayed on farm fences. Despite this they are still moderately common around forest margins and now protected by law. The Black Swan is still one of our most abundant birds although it has been shot as a pest and its nests destroyed, the young used for food, and its eggs "used by the cart load" before it was protected. If we ascribe the demise of the Pied Goose and Brolga to the drainage of swamps, it is more difficult to explain the success of the Black Swan.

The smaller birds which are now regarded as game (ducks, quail, and snipe) all exhibit extreme natural fluctuations in local density because of migration, nomadism, and response to local conditions. All eight species of ducks which were common in 1850 are still widespread in Victoria although total numbers have undoubtedly fallen with the drainage of wetlands. The decline around Melbourne was already obvious by 1860 when it was observed that "a few years ago . . . these morasses and fens . . . must have swarmed with wild-fowl . . . (but) . . . the swamps and lagoons are all drained or built on".

In 1888 it was recorded that "on top of Pine Mountain the Rock Wallaby is very common and may be seen jumping about in all directions", and some ten years later: "It is fine sport this wallaby shooting (and the) graceful and active animal is generally found in herds of about ninety in number". Today rock wallabies survive only in tiny family groups in two or three places in Victoria. The "fine sport" may have contributed to the rapidity of their decline, but some other change must have occurred which now prevents the remaining animals breeding up. This was probably the introduction of the rabbit, goat, and sheep as competitors for food, and perhaps the fox and cat as predators of young wallabies.

By comparison with the plagues of last century, rabbits are now "under control", but they are still the most common mammals in Victoria today. The native animals which suffered most from their introduction were those with similar ecological needs—small grazing or burrowing mammals of the plains. Records are fragmentary, but of the mammals thought to occur in western Victoria before 1860, about fifteen species are now extinct in the State including

stick-nest rats, the rabbit-bandicoot, the hare-wallaby, nail-tailed wallabies, and bettongs.

A more puzzling loss is that of the native-cat. In 1850 it was "one of the commonest of all bush animals . . . very destructive to birds, especially poultry". They thwarted an early attempt to establish wild rabbits on the Loddon about 1845. Six hundred and twenty-two were shot in a month near Geelong about 1867. By 1885 attitudes had changed: "The Vermin Board Conference (resolved) that the native-cats . . . should be declared natural enemies of rabbits, and protected from destruction". It was too late; numbers in the Stony Rises had declined noticeably. They recovered somewhat in 1886. In 1900 their prowess was in doubt: "It was a pity that the native-cat does not take to preying on rabbits," and in 1905 native-cats were still said to be much more numerous than either dingoes or tiger-cats.

The last colonies known in Victoria were near Colac in the 1930s and Studley Park, Kew, in the 1940s. There still appears to be ample habitat and food and no serious competitors for this fierce, efficient carnivore and no satisfactory reason has been suggested for such a protracted decline. It is still common in Tasmania.

Snakes and lizards have never been serious pests in Victoria, nor been used for food or commerce, so that historical references to them do not provide much basis on which to judge changes in local abundance. In western Victoria reptiles generally, like birds and mammals, suffered a serious contraction of range due to extensive clearing for agriculture especially in the Mallee, and most of the original species survive only on reserves. In eastern Victoria, by contrast, the partial clearing of dense forests has actually proved an advantage to reptiles since most of them require exposure to the sun and the forest openings allow them to extend their range to places which were formerly too shaded.

Amphibians probably decreased in total numbers in central and southern Victoria as a result of swamp drainage, but they may have gained some advantages in irrigation districts to the north.

Rainfall and stream flow in Victoria are very variable. The ecology of freshwater organisms is attuned to this, but water conservation and flood control techniques aim to minimise this variability and most indigenous fish have been adversely affected. The clearing and grazing of stream banks is also deleterious. The Australian grayling has declined most seriously, but Macquarie perch, freshwater catfish, golden perch, silver perch, tupong, blackfish, and Murray cod have all waned.

Rabbits seriously damaged vegetation and soil, and this had serious consequences for the indigenous fauna. It is much harder to recognise the effects of other introduced animals. Fortunately most failed to survive but starlings, house sparrows, blackbirds, foxes, feral-cats, house-mice, brown trout, English perch, and European carp are now among the most widespread and abundant elements of the fauna. Some others established more localised populations. All of these seem certain to prey on, or compete in some way with native animals, but the relationships cannot be measured. Apart from the rabbit, the most harmful introduction may yet be the European carp, because it too causes fundamental changes to the habitat which render many streams and reservoirs unsuitable for other more desirable fish.

For the majority of Victoria's animals there is no available record of change. Only now are accurate techniques being devised for measuring and recording abundance and distribution, so that biologists in future will have a better basis for the detection of change.

MINING

Minerals have played an important part in stimulating settlement in Victoria. Two minerals, gold and brown coal, have been most influential in this regard.

The first was gold and its discovery had immediate and far-reaching effects. The second was brown coal which, although first discovered only six years after gold, did not become important in Victoria's economy until more than sixty years later. Many other minerals and industrial rocks were also important but, in most cases, their exploitation occurred as a result of settlement rather than the reverse.

The gold discoveries of 1851, first at Clunes and Andersons Creek (Warrandyte), and the gold rushes which followed, disrupted Victoria's predominantly pastoral economy, depriving existing industry of men and providing the greater part of the State's income for a decade. Export income from gold actually exceeded that from wool until 1874.

During the period from March 1851 to April 1861 the population increased from about 77,000 to almost 540,000 and, at the peak of activity in 1858, about 140,000 men were directly engaged in mining. By 1861, Victoria had yielded at least 709 million grams of gold, an appreciable part of the 2,100 million grams approximately found up to the present time, and between 1852 and 1860 an average of over 56.7 million grams was being mined annually.

However, from the late 1850s to 1870 the amount of gold produced was only about 25 per cent of that produced previously. This decline was offset by the impetus given to the community as a whole by wealth from gold and by immigration, also stimulated by gold. City industry, farming, and pastoral pursuits expanded and attracted men away from mining.

Goldmining

At first the gold won was in shallow alluvial deposits. However, deeper sinking commenced in 1853 to exploit deeper alluvial deposits and gold-bearing quartz reefs. Open cut mining also started about the same time, for example, by Ballerstadt at Bendigo. The effects of this activity on the environment are described on page 21.

The early rushes to Ballarat, Mount Alexander, Clunes, and Bendigo were followed in the second half of the 1850s by rushes to St Arnaud, Dunolly, Beaufort, Ararat, Stawell, and other places in the Midlands. Goldfields were also opened up in the north-east at Chiltern and Rutherglen, and discoveries were made in the more mountainous country of eastern Victoria–Omeo in 1852 and Reids Creek (Beechworth) soon after.

In the 1860s numbers of gold finds were made in the rugged country of north Gippsland at Stringers Creek (Walhalla), Gaffneys Creek, Jericho, Jordan River, and others. Woods Point was thriving in 1866.

Many other mostly small fields were also discovered extending from Mount William in the west to far east Gippsland and to Turtons Creek in south Gippsland.

The stimulus given by gold to the opening up of the country was most marked around the central goldfields area, particularly as there was land suitable for agriculture in close proximity. In fact, between 1856 and 1861 the number of holdings in the four counties covering the main goldfields, Ripon, Talbot, Dalhousie, and Grenville, increased from 560 to 3,350. Cultivated land in these counties also increased to about one third of Victoria's total.

The tracks to the goldfields were soon well defined and eventually became the main access routes to established centres and agricultural districts. Eventually railways followed the main routes (Ballarat, Castlemaine, Bendigo, and Maryborough were examples). Numerous roads also radiated from the gold centres themselves, first as tracks to local finds, then as timber tracks for fuel and timbers for the mines, and finally as access roads to the land cleared for agriculture.

In the mountains, however, access was difficult and agriculture severely limited; the main routes to the goldfields were fewer and often have remained

the means of ready access to these areas. The network of tracks traversing the auriferous areas were mostly abandoned with the decline of mining. The richness of the Walhalla area prompted the building of a railway line from Moe, but this only reached the field as the mines declined and it was subsequently abandoned.

Within and adjacent to the goldfields the effect on the environment was marked. Forests were cleared, deposits on the hill slopes stripped off, and the alluvials in the valleys worked over extensively. As deep mining developed, larger mullock dumps appeared often aligned along "lines of reef" or along buried alluvial channels (deep leads). Treated sands from the mine batteries were settled in valleys or as larger dumps and sludge from sluicing operations flowed down the watercourses (see page 24).

At first there was little control of this waste disposal but later stringent conditions were enforced, following the establishment of the Sludge Abatement Board in 1905.

The intensive activity of the rushes within a few years depleted the easily won near-surface gold. By following surface indications, such as outcropping quartz reefs and gradually deepening auriferous alluvials, deeper gold was exploited and depleted. Then by using the accumulated knowledge of the principles of gold occurrence, deeper deposits without direct surface indications were explored for, with variable success.

Life on the goldfields in the early days was hard and amenities few. Government control was oppressive and this resulted in much unrest and finally armed resistance.

Deeper mining increased the risks: the danger of mine collapse, of sudden flooding, and of the more insidious silicosis.

There were also the financial risks, the chance of not finding payable gold and the chance that the gold would suddenly run out. There were also the difficulties of prospecting rough, remote terrain and the possibility of diseases such as dysentery.

Some stayed on the goldfields, working in the relatively few mines which were able to continue operating. Others became engaged in prospecting, taking up farming, business, or trade. Most of the diggers, however, were transient.

Coal and other minerals

Although the discovery and early exploitation of brown coal occurred several decades after first settlement, its effects on providing energy sources for Victoria and prompting the development of new population centres was highly significant. Brown coal was discovered in 1857 at Lal Lal and by 1864 coal was being sent to Geelong, Ballarat, and Melbourne. However, the venture was not successful. By 1876 there were 32 known brown coal localities.

As a result of the 1887 Royal Commission on Coal, diamond drilling for black coal commenced early in the 1890s. These operations incidentally revealed the wide distribution of brown coal.

In 1894 a briquetting plant was established at the Great Morwell (Yallourn North) open cut, but this fuel did not compete successfully with black coal. In 1916 the Yallourn North open cut was reopened to obtain emergency fuel during the Newcastle coal strike. This prompted an intensive search for brown coal by the Mines Department which continued until 1922, to be resumed later by the State Electricity Commission of Victoria.

The State Electricity Commission was instituted in 1919, and took over the winning and briquetting of brown coal as well as power generation which commenced in the early 1920s. Private production of brown coal also commenced about this time, for example, at Bacchus Marsh and Gelliondale. These small operations provided some employment locally, but it was the

large scale operations of the S.E.C. which had important results, not only in the La Trobe valley where the coal was mined and processed and electricity generated, but State-wide through the provision of fuel and power to developing industries and towns and for domestic purposes.

Black coal was first discovered near Cape Patterson by Hovell in 1826. Other discoveries were made there in 1856 and the first mine was opened in 1859 but transport difficulties forced its closure. Later, more accessible fields were discovered at Jumbunna, Korumburra, and Outtrim.

The largest black coal mining operation was that of the State Coal Mine at Wonthaggi which opened in 1909. The annual production from this mine for some years was of the order of 508,000 tonnes. Before this the total production for Victoria had been less than 203,000 tonnes. The opening of the State Mine resulted in the growth of the town of Wonthaggi and assisted development in other parts of the State by providing coal for the railways.

Ever since the early days of settlement many kinds of minerals and rocks have been important to all developing communities. Broadly, these commodities fall into two groups: those which have properties required for special purposes sufficient to warrant their transport over appreciable distances, and those whose use is essentially local. The first group includes ornamental stones, such as Harcourt granite which was used in many early Melbourne buildings and slate, such as that from Barbers Creek, used for paving city footpaths. Other materials in this category include salt and gypsum from the north-west of Victoria, limestone, diatomaceous earth, and some high grade pottery clays. The second group includes products, the use of which is essentially local and the availability of particular materials is often reflected in early buildings and other structures. This can be seen, for example, in the aeoliamite sandstone buildings of Warrnambool, the sandstone and slate construction of the goldfields, and the basalt fences and buildings of the volcanic plains. The occurrence of clay suitable for brick-making was also important and in some areas, the Gippsland plains for example, this was the only material, other than timber, which was readily available.

APPRAISING THE LAND

The preceding sections have shown how each of the various features of the land, for example, climate, geomorphology, and soil, has influenced the way in which land was used in Victoria. It has also been seen that land-use itself has left its mark in unexpected, sometimes undesirable, ways.

From this two important principles emerge. One is the need for an integrated approach to land appraisal; the other is the importance of keeping the concept of conservation in mind when doing so. In addition, there should be adherence to the principles of classification because, when different kinds of land are under appraisal, in effect they are being classified. Finally, the fundamental objectives in land-use must be heeded.

Such an approach to land appraisal is discussed here under three headings: the general principles of approach; a Victorian example of the approach as a whole; and Victorian examples of three contrasting types of land.

General principles

The chief aspects of a proper approach to land appraisal are determined by the four factors already mentioned—concepts of conservation and classification, the integrated approach, and one's basic purpose.

First, the purpose. When land is appraised, the intention is to estimate its total worth, not only its economic value. Consequently the purpose of land appraisal is to establish the most worthwhile use of the land. This, however, partly depends on what the community needs and on the resources available for producing it—that is, on socio-economic data. The approach must be designed to take account of socio-economic as well as physical factors.

As for conservation, it is the husbanding of resources—preventing an impairment of the ability of the resource to produce whatever is needed from it. Accordingly, a range of uses of the land must be envisaged. Also, potential processes have to be considered because this allows an estimate to be made of the hazards of possible impairment resulting from those processes or uses.

When land is classified, one of the aims is to predict information about the land regarding its use. Thus the predictive ability of the classification system and the relevance of the predicted information are important.

In general purpose systems of land classification, consideration is given to many possible uses of the land, for each of which some particular feature is relevant. It is important for the land features to be highly correlated to ensure a high predictability for each feature. Consequently data is needed on many land features. On the other hand, in special purpose systems of land classification, only one particular use of the land is considered, in which case the important thing is to know the relevant features for that particular use. This in turn involves a knowledge of processes.

The integrated approach is the inter-relating of the various land features and site conditions, followed by considering its significance for productivity and management in various types of use. There are two reasons for this integrated approach. First, the productivity of the land depends upon many features, consequently all should be considered. Second, features interact and differ in importance according to the circumstances. Consequently something about those interactions should be known before each feature can be properly emphasised.

From the above, five important aspects of a system of land appraisal are :
(1) Data on a number of features and their relationships ;
(2) considering various kinds of land-use ;
(3) a knowledge of the relationships between features and performance ;
(4) a knowledge of processes and hazards ; and
(5) the use of socio-economic data.

First, the land is characterised in terms of each of its chief features. This is done in the form of the pattern of the features, so that large areas can be described quickly and the relationships shown clearly. Patterns are usually repetitive sequences of certain values of the features—for example, a topographic sequence from crest to hollow.

Second, the capability of the land is considered in a number of forms of land-use rather than simply in some preconceived kind of production. This ensures that much fuller information is used in making land-use decisions which are the better for it.

Third, in interpreting the features of the land in order to estimate the performance, two methods may be used. One is the empirical method wherein the performance of a particular area of land is noted. This performance is assumed to apply to other areas which are apparently similar—that is, to the balance of the mapping unit.

In the other method, the rational method, interactions are studied between land features such as the rainfall regime or soil physical features, with the management inputs, such as fertilisers and cultivation, in producing the various site conditions, such as the water status of the topsoil during a particular season. These site conditions closely determine the productivity. Their interactions, in turn, are then considered for each kind of production. The twin aspects of land-use are the kind of production and the management practices appropriate to it.

The word "appropriate" leads into the fourth, or conservation, aspect which involves assessment of land-use hazards and the safety of the proposed management practices. Prediction of hazards is important, because the demands made on Victoria's limited land resources are becoming increasingly heavier. Again, two methods can be used in making these predictions. In the empirical

method, a knowledge of what has already happened can be extrapolated to apparently similar situations. This, however, was not possible at the time of settlement because the settlers, with their time-tested European management practices, had no experience of applying them in Victoria. Nor, able and far-sighted though many of them were (for example, Robertson of Wando Vale and James Bonwick, Inspector of Denominational Schools), did they have the technical background to make rational predictions. This places a greater responsibility on the present generation, because it now has examples of what can happen, and has a fuller knowledge of the technical processes in the land. On this knowledge rational predictions can be based.

Finally, there is the matter of socio-economic and policy data. Among the many basic changes in land-use over the past few years in Victoria, one of the most important has been the great questioning of aims and objectives. These may vary between food or wood, wildlife or solitude, or just financial gain. In the future it will no longer be sufficient to permit the use of land to be determined without looking ahead and conserving it where necessary.

Victorian example of the approach as a whole

The approach has four stages which together comprise the five aspects listed above. The stages are:

(1) Characterising the land in terms of its features and their relationships;
(2) estimating its capability in various kinds of production;
(3) predicting the hazards; and
(4) coming to an opinion about the most worthwhile use of it.

The example chosen is the area of sand dunes and sand plains west of Casterton, near the South Australian border.

Characterising the land

The landscape pattern is the means of showing the features and their relationships. Patterns may be at different scales, degrees of detail, and precision. Three scales are commonly used—land zones at the smallest scale with least detail and precision, land systems, and finally land units at the largest scale with most detail and precision.

The Kanawinka land zone very broadly characterises the whole area of acidic sandy country west of Casterton. The Follett land system is that part of it on the Follett plains, and the Tooloy land unit characterises an area of about 12,000 hectares of the Follett land system near the Parish of Tooloy. The segments of each of these patterns are arbitrarily defined and are known as " components ".

Estimating the capability in various kinds of production

This is done at the level of detail appropriate to the pattern and on the basis of the components, because the components may differ in capability. The Follett land system is used here as an example. The intention is to consider pastoral use, forestry, parkland values, and water supply.

Inspection of the pastorally developed parts of the land system reveals that the likelihood of success in establishing improved pastures is closely related to the depth and acidity of the sand mantle. The pastoral potential of the various components can then be gauged.

Similarly the forester, from his knowledge of the requirements of pines and of their performance in the district, can estimate the suitability of the components for pine plantations. Here, doubt exists about the continued satisfactory growth rates on the deeper acidic sands, even with the aid of fertilisers.

With its profusion of heath species, the haven for small animals, and the importance of the swamps for birds, appreciation of the high values of this land type for parkland and wilderness has been only recently developed.

As to water supply, the climate and topography do not allow strong stream flows, but Mines Department geologists have shown that three separate underground strata are water bearing and offer very useful present and future bore supplies.

The common denominator in all these estimates of capability is the application of empirical and rational methods by people trained in various skills and disciplines.

Predicting the hazards

This type of land was taken up in the 1840s to form large runs, but most of it soon reverted to the Crown because of apparent infertility. Development for pastoral and forestry purposes started only after the Second World War, so that there has been little time for hazards to become manifest and so serve as examples.

However, if the possibilities are examined rationally, water erosion will not be a serious problem in view of the high permeability of the coarse sands and the absence of long steep slopes. Surface aquifers are generally not salty and no widespread salting problems, resulting from over-clearing and consequent raising of the water table, can be foreseen. Sandy soils are notoriously susceptible to wind erosion, but the absence of a system of farming with regular fallowing and cultivation, a moderate rainfall, and the tendency of bracken to colonise the deep sands, minimises the risk of severe wind erosion.

The chief hazard, in fact, is likely to result from the very factor which caused the early settlers to abandon the area—the low nutrient status and water holding properties of the deeper sands. There is no doubt that generous application of fertilisers is needed to sustain production on these soils, but the level of productivity to warrant that expense may be difficult to achieve on soils with such low water retaining capacity and unfavourable chemical conditions for extensive root development. The fertility of the soils is precarious.

Best use of the land system

Where the deeper sands predominate, as over most of the land system, the hazard precludes any form of management which is exploitable to the slightest degree. There is no one kind of production which is clearly most worthwhile solely on the basis of capability at the high levels of input which must be given. On the shallow sands, the case for pastoral use and for plantation forestry is stronger, but overall, the matter is not clear cut. These are circumstances where the "non-committal" conservation principle is applicable—the notion of keeping the land in the condition in which it can meet, most easily, future requirements—that is, to leave it as it is for the moment.

This particular example of the approach to land appraisal thus presents no clear cut conclusion. Such a conclusion derives from characterising the land, assessing its capabilities, looking at the hazards, and evaluating it all. This approach can still be applicable to areas of rapid change—for example, the "rurban" areas, which are the 1970s version of land settlement in Victoria. In urban areas precise answers are possible as to where and where not to build houses, roads, and to set aside parks. The important thing is not that the approach should lead to clear cut conclusions, but to correct and reliable conclusions.

Victorian examples of three contrasting types of land

The examples are: Eastern Highlands, Dissected Tertiary fringes of Highlands, and coastal sand sequence. Each example includes two or three adjacent land zones and is broadly representative of a significant part of Victoria.

The significance of the features for capability, settlement, and hazard is briefly explained in the following paragraphs.

Eastern Highlands

The chief features are the steep slopes stretching from the cold, wet high plains down through the productive forests of woollybutt, narrow-leaved peppermint, broad-leaved peppermint, stringybark, boxes, and gums to the warmer, drier, lowland fringe. Well structured, porous, deep loams in the higher ranges safely take the great excess of water from snow or rain to the streams, provided that roads, tracks, and trampling do not channel the flow and reduce the porosity.

The steep slopes and climate have restricted settlement to the lower fringe. There, hard topsoils and tight subsoils throw off the water from cleared slopes to erode the gullies and to sully the streams. Thus, proper management must be based on land classes identified by the degree and length of slope.

Dissected Tertiary fringes of Highlands

At the base of the Highlands, the Tertiary peneplain was formed. Ironstone—capped and now dissected, it is typified around the Highlands near Sale, south of St Arnaud, at Cobden, but especially west of Hamilton.

The plateau is parklike with indigenous red gums, but the dissected areas beneath vary with the rock type exposed. At Coleraine and Casterton, it is the soft, calcareous Mesozoic mudstones which, in that climate, produce dark, cracking clays, carrying originally almost treeless grasslands, even on steep slopes.

Thus the area was most attractive for settlement, easiest to develop, and quickly rewarding country in the early years of settlement. The first eight inland stations in western Victoria, all settled from Portland, were on the Casterton land system. Merino Downs, Muntham, Sandford, and Connell's Run were settled by the Henty family, and then came Murndal, Tahara, Hilgay, and Wando Vale. The five settlements following these, at Dunrobin, Nangeela, Warrock, Cashmere, and Wannon Falls, were on the periphery of the land system and included parts of adjacent land systems, particularly Glenelg and Dundas. By the time the stream of new settlers from eastern Victoria arrived in 1840, virtually the whole of the Casterton land system, but not much outside it, had been taken up. The newly arrived settlers occupied the remainder of the Glenelg and Dundas land systems.

Nevertheless, despite its high fertility, the land zone is extremely prone to mass movement because of certain properties of the dark clay soils when saturated. As a result, over-grazing caused vegetation changes which reduced the transpiration of water and caused the soils to be saturated over a longer period each year. Holes in the ground extended upslope by slumping and became huge gullies, and earth flows started on the slopes. Robertson of Wando Vale, writing in 1853, graphically describes how, ten years after settlement, deterioration first appeared. Two years later most of the erosion forms which are today familiar were widespread. Only during the last fifteen years has a significant reversal of erosion been achieved.

Coastal sand sequence

Wherever the Victorian coast presents a broad front to the prevailing south-westerlies, the combination of tide and wind has thrown up huge piles of sand which, at various times during the Quarternary period, were swept inland.

Three distinct adjacent zones of sand deposits can nearly always be found; those further inland are comprised progressively of older, flatter dunes of more acidic sand. The sequence is found between Capes Liptrap and Paterson, along the Melbourne bayside suburbs, west of Cape Otway, but especially along

Discovery Bay, where the inland extent has been stretched by the retreat of the sea since Tertiary times.

The inland zone, in that area, is the Kanawinka land system described earlier, with infertile, highly weathered and sorted acidic sands. The intermediate land zone is the Nelson land system with orange sands and limestone dunes. These were among the earliest areas to be settled, as around Warrnambool and Bridgewater Bay, and are ideal for growing lucerne and pines. Fringing the coast is the zone of unweathered calcareous sand, too alkaline for anything except coastal scrub and Marram grass, and very susceptible to wind erosion.

These three examples of contrasting land types have been chosen, but others could just as well have been taken—the basaltic plains of Western Victoria, where the pattern is based on age of basalt flow; the Mallee; the Wimmera; the Bendigo goldfields; the Northern Riverine plains; or the Otway and Gippsland hills. In all, however, the same approach to land appraisal is applicable—the objective and comprehensive characterising of an area of land, assessing its various capabilities, determining its hazards, and evaluating all these factors in the context of social and economic circumstances.

CONCLUSION

Further articles in this series on the emergence of Victoria's environment and its relation to man will detail major aspects of that relationship. This survey of Victoria at the time of settlement has suggested certain common features which were to have their impact on future developments. These features one detects with the benefit of hindsight.

The first was the degree of ignorance about the nature of Victoria's ecology. This was the unavoidable by-product of early settlement. A country so far distant from Britain with a climate outside the range of previous experience and a vegetation and fauna far removed from European precedents—such features made an appraisal of the environment which would now be deemed rational, virtually impossible then. One also notes that although there was a wide knowledge of natural history in the northern hemisphere, there were only a few brilliant people who really understood the meaning of this knowledge. In the overall situation ecology had no place; Victoria was no different from the greater part of the world in this regard.

Second were the pressures, at first, of basic economic necessity and later of the spur to gain wealth. Only when these aims were fulfilled did it become possible to contemplate the environment with objectivity if not with detachment.

Third was the inability to realise that the effects imposed on the original ecology would be virtually irreversible and only tempered many generations later through careful husbandry and conservation.

Fourth was the virtual absence of any planning in the initial exploitation of resources. The surprising extent of the land area and its natural resources did little to prompt the early settlers towards a degree of care that seems self evident to the present generation.

Fifth was the slow realisation that the effects of man on his environment from exploitation—for however cogent a set of reasons at first—was likely to become a reversible equation. The extinction of native grasses, the visible demise of faunal species, the pollution of streams, and the despoilation of the landscape were, after some years, seen to threaten the well-being of man himself.

The very great efforts needed to redress the balance—to stabilise the equation, as it were—were to become the chronicles of subsequent efforts through prevention, legislation, and planning. How this came to be achieved in such areas as farming, afforestation, and mining, and how attempts were to be made to make quantitative assessments of the total environment, will become the subject of succeeding articles.

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