RESERVE MANAGEMENT CONSULTANT'S REPORT No. 1

THE POLICIES, PRINCIPLES AND PRACTICE OF FIREBREAK CONSTRUCTION AND MAINTENANCE FOR NATURE RESERVES IN WESTERN AUSTRALIA

by

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DEPARTMENT OF FISHERIES AND WILDLIFE 1983

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These initial steps forward were greatly aided by discussions with Mr. K. Wallace, Reserves Management Officer, Pingelly, who ably identified problems of firebreak construction and maintenance in the central wheatbelt. From his unpublished work, data were supplied on reserve sizes which became the basis for recommendations on minimum compartment size and area to be used for firebreaks.

The special problems of firebreaks on sandy soils were explained, and examples shown, to the author by Mr. G. Foley, Ranger at Two Peoples Bay Nature Reserve, and Mr. A. Mangini, Ranger at Woodvale Nature Reserve. Mr. Foley also highlighted the problems and advantages of slashed low fuel firebreaks.

Mr. G. Graham advised on the practical problems of construction and maintenance as experienced over the whole of the firebreak system as it presently exists, while Mr. A. Williams provided helpful suggestions through the formative stages.

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In many ways much of what follows is a synthesis of the knowledge of these people on this subject.

Graeme R. Chatfield

High Wycombe. January 1983.

INTRODUCTION

Much of what follows is obvious common sense. Yet it is an unfailing characteristic of man to overlook the obvious and fail to act with common sense. This document has been compiled so that these things will be applied to the problems of firebreak construction and maintenance on nature reserves in Western Australia. The hope is that it will provide a basis for a thoroughly organized and preplanned approach to the construction and maintenance of firebreaks.

The document has three major sections. Section One deals with the general principles of firebreaks: their purpose, function and reasons for being on nature reserves.

Section Two looks at the practice of firebreak construction and maintenance. The different types of firebreaks, the advantages and disadvantages of each, in conjunction with the factors that determine the design of firebreak systems, are considered.

Section Three draws together from the preceding sections a series of policies for the construction and maintenance of firebreaks on nature reserves in Western Australia.

SECTION ONE: GENERAL PRINCIPLES

As firebreaks are only one of a number of wildfire control measures, it is convenient to discuss them on their own, highlighting their special characteristics and significance.

DEFINITION

For the purpose of this paper a firebreak is defined as a strip of land from which combustible fuel has been removed or reduced. A second group includes those natural features of the landscape, such as lakes and lithic complexes, which act as barriers to the spread of fire.

WILDFIRE CONTROL

Man-made firebreaks have traditionally been used as a first preventative step in wildfire control. They have been constructed around areas of high value and/or high fire risk, with the intention that any wildfire threatening the area can be stopped. This is achieved either by the firebreak itself, or by the combined effects of the break and the intervention of firefighters.

STOPPING WILDFIRES

In theory, a firebreak will stop a wildfire by breaking the progression of the fire spread. Only the width of the firebreak needs to be altered in relation to the intensity of the wildfire it is intended to stop. The spread of a wildfire by means of heat radiation and direct flame contact can be stopped by a sufficiently wide bare earth break in mild fire danger conditions.

Wildfires also spread by means of wind borne firebrands igniting new fires well in advance of the fire front. In extreme fire danger conditions spotting has been recorded as far as 30 km from the main front. This spotting characteristic is more prevalent in *Eucalypt* woodlands and forests, where annually shed outer bark proves to be ideal material for firebrands.

In extreme fire danger conditions, the width of the break required to effectively stop a wildfire would become quite impractical.

RATE OF SPREAD

In all fire danger conditions firebreaks can slow the rate of spread of a fire. Bare earth firebreaks do this by interrupting the fire's progress and forcing it to spread by means of spotting beyond the break. It will take time for a spot fire to become an established major fire. Low fuel breaks fulfil the same function by reducing the intensity of the fire crossing the break. Though fire can creep across these breaks, they do have distinct advantages in terms of access, particularly in erosion susceptible soils, to bare earth breaks.

The total area of a reserve affected by a wildfire will depend, in part, on the time it takes to instigate suppression measures. Firebreaks gain time by slowing the rate of spread of wildfires, thus helping to reduce the destruction of conservation values of nature reserves.

ACCESS

Both bare earth and slashed low fuel firebreaks provide access for fire-fighting units to directly attack a fire. They also act as lines from which back burning can be safely initiated, and spot fires in close proximity to them can be extinguished.

The condition of a firebreak should be such that it aids access of men and vehicles to the fire area. Erosion of the firebreak surface is a major problem, hindering the safe movement of fire-fighting units, and negating some of the break's value.

In heath vegetation on sandy soils, which are particularly erosion susceptible, the slashed low fuel break provides safer access for fire-fighting units than the more traditional bare earth break.

COMBINATION FIREBREAKS

Combinations of bare earth, low fuel and natural firebreaks increase the effectiveness of wildfire control by providing a wider strip of ground acting as a fire barrier. Other advantages include the provision of a strip of vegetation more easily and safely back burnt in a wildfire situation, and reduced problems of erosion, with its inherent danger in terms of access.

FIREBREAKS ON NATURE RESERVES

By definition man-made firebreaks on nature reserves involve the disruption of the natural environment. Construction of firebreaks appears to be contrary to the purpose of nature reserves, which is the preservation of representative areas of Western Australia's natural ecosystems. Firebreak designers need to give this matter very careful consideration.

There is an element of compromise in firebreak design between the desire to maximise protection from wildfires, and the need to minimise costs. Costs involve both financial costs of man hours and machinery hire, and the cost to the environment from disturbance due to firebreak construction. In each case of firebreak system design the planner is involved in this cost-benefit study.

As at 1 July 1982, there was a total of 3196 km of firebreaks on nature reserves in the south-west of Western Australia. These were constructed because it was demontrated that the benefits to the nature reserves well justified the costs incurred. These costs and benefits are the subject of the following discussion.

PROTECTION OF CONSERVATION VALUES

Perimeter and internal firebreaks are seen to benefit nature reserves firstly by restricting the entrance of wildfires onto reserves, and secondly, by reducing the area affected by any one fire. Unaided, perimeter breaks may stop mild wildfires from entering a reserve. Through the combined effects of the break and the efforts of the fire-fighters patroling the firebreak and extinguishing spot fires jumping it onto the reserve, severe wildfires can be halted at the line of the firebreak. Perimeter breaks are seen as a first line of defence against the invasion of reserves by wildfires.

Where a wildfire successfully jumps the perimeter break, it will take time for it to become a major wildfire. The time taken to establish itself is time gained for the fire-fighting units to reach the site of the fire.

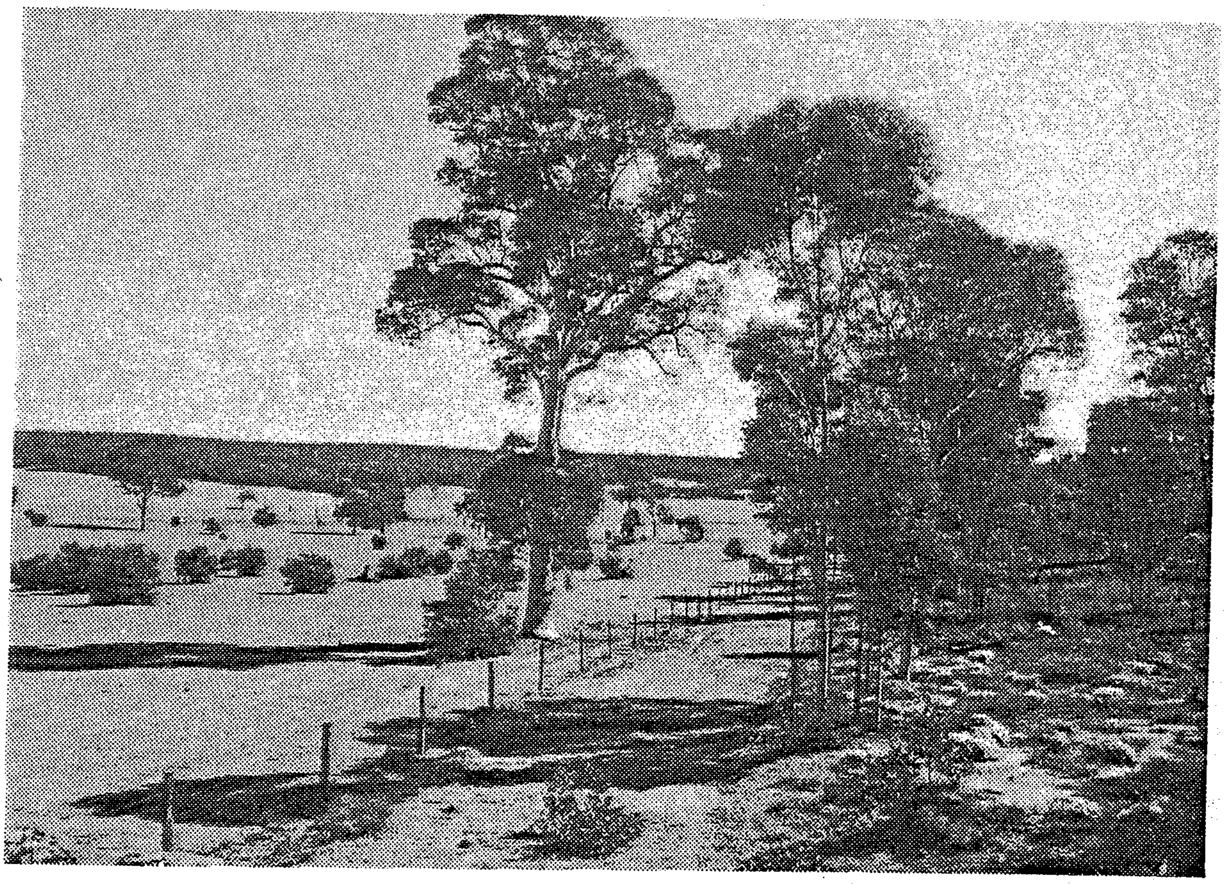

Fig. 1. The first line of defence. A good perimeter firebreak on laterite soil protecting both the reserve and adjoining property.

A wildfire on a nature reserve can be fought from a second line of defence, the internal firebreaks. The construction of internal firebreaks compartmentalises the main body of the reserve. The intention is to restrict any one wildfire to the minimum number of compartments, thus reducing the possible total area of the reserve affected by fire. The breaks that form the boundary of a compartment help to isolate a wildfire to that compartment as firefighters can combat the blaze from these lines.

The placement of these internal breaks also requires some thought to the matter of seral stages. One of the aims in nature reserve management is to maximise the habitat diversity of a reserve. The placement of internal firebreaks can be seen as a means whereby the most diverse potential of seral stages can be provided for. This matter of placement will receive fuller attention in later discussion.

PROTECTION OF LIFE, PROPERTY AND ASSETS

Nature reserves are part of an established pattern of land use. As such the reserve manager should act as a responsible neighbour and provide for the protection of life, property and assets on adjacent land. This is important in areas where reserves share common boundaries with fenced farmland. In some instances reserve neighbours see reserves as a source from which fire can escape and damage their property. To alleviate this perceived threat, perimeter firebreaks have often been constructed on reserves after discussion with reserve neighbours.

Where nature reserves are adjacent vacant Crown land, consultation about firebreak design between the reserve manager and Government agencies responsible for the area of vacant Crown land should occur so that the different goals of both managers can be achieved to their fullest extent.

DIVISION OF LARGE AREAS

The construction of internal firebreaks is seen to be beneficial to nature reserves by dividing large areas of bushland into more manageable sizes for wildfire control. In a fixed area the greater the number of internal breaks, the smaller the compartment size. If wildfires can be confined to a limited number of compartments the total area affected will be reduced where compartment sizes are smaller.

The rate of spread will be decreased as the fire will have to jump a larger number of breaks. Greater access will be provided to more parts of the reserve by a larger number of internal breaks, facilitating firefighters' abilities to attack the main fire from the line of a firebreak.

The greater access facilities will also aid in biological survey work by allowing easier access to more of the reserve.

However, increasing the number of internal firebreaks increases the costs involved. The total area committed to firebreak construction will increase dramatically, as will the financial costs of construction and maintenance.

The greater access to the remoter parts of a reserve provided by larger numbers of breaks will potentially expose large areas of the reserve to activities, such as rubbish dumping, exploitation of the flora and fauna, introduction of weeds and noxious plant species and so on, which are detrimental to the conservation of the natural environment.

It is the planners' responsibility to ascertain when costs outweigh benefits and to adjust firebreak designs accordingly.

RESPONSIBLE ADMINISTRATION

Shire by-laws require landholders to install minimum width firebreaks on their property, or, in some Shires, to provide adequate fire suppresson equipment as an alternative. Though there is no legal requirement for firebreaks to be constructed on nature reserves, it is considered prudent to construct breaks on reserves which satisfy the minimum Shire requirements. In this way the Department of Fisheries and Wildlife is seen to be acting as a responsible neighbour by satisfying the same legal requirements as adjacent landholders.

Firebreaks are an obvious method of demonstrating that an area of bush-land is being actively and responsibly managed, a matter that can be brought up during discussions with reserve neighbours on firebreak design. Also during these discussions the complete design should be finalised. This will reduce the possibility of installing only perimeter breaks initially and later having to construct internal breaks with increases in costs being incurred. If no internal breaks are deemed necessary, this should be made clear, with the appropriate reasons, early in discussions.

Should a wildfire escape a firebreaked nature reserve and damage neigh-bouring property, the Department is protected from accusations of irresponsibility, as protective measures equivalent to those taken anywhere else in the Shire had been taken.

SECTION TWO: PRACTICES

The total distance covered by firebreaks on nature reserves in Western Australia as at 1 July 1983 was 3196 km. This represents an estimated capital outlay of $700 000 for construction, and requires an approximate annual outlay of $11 400 to maintain about half this distance.

The costs are not insubstantial and care must be taken to ensure that the construction and maintenance of firebreak systems on nature reserves in Western Australia is as cost efficient as possible, while providing maximum protection of the conservation values of the reserves.

Cost efficiency is not achieved by skimping on the time spent in the initial construction and the first three years of maintenance. It is better to thoroughly prepare the firebreaks in these years and then be able to reduce the frequency of maintenance to be sure of the effectiveness of the firebreaks throughout the whole period.

WORK PRIORITY

Limitations on finances will involve giving priorities to firebreak construction work. The priority of the work may be determined by considering fire risk, reserve conservation values and neighbouring values. These considerations are taken up in the following discussion.

Once constructed a firebreak must be maintained. Not to do so squanders the limited financial resources of the Department and needlessly lowers the conservation values of the affected area.

As the total distance of firebreaks on nature reserves increase, so do the demands for finance and manpower. This is even more likely as the Department is seen to be managing reserves actively and the requests for firebreaks increase. To cope with this increase in demand for firebreaks, more manpower will have to be used in the planning of such systems. The need for the long promised Katanning and Wongan Hills Reserves Management Teams becomes increasingly desperate and apparent.

Until the manpower becomes available, much of what follows will of necessity remain only an ideal.

CONSERVATION VALUES

The conservation values of nature reserves differ from reserve to reserve. Depending on these perceived values, the firebreak system designed to protect them may vary from a minimum 3 m wide bare earth perimter break, to an elaborate system of bare earth, low fuel and combinations of these types of firebreaks with natural firebreaks as is presently maintained on Two Peoples Bay Nature Reserve. Some of the factors that influence the grading of conservation values are discussed below.

Rare Flora

Rare flora are those species of plants gazetted under the provisions of the Wildlife Conservation Act 1959, as amended. The preservation of known populations of rare flora requires careful management. Where a population occurs on a nature reserve, provision should be made to protect it particularly from the degenerating influence of too frequent fire. The design of the firebreak system may need to commit larger areas of the reserve in the form of firebreaks to protect the rare species than would be the case if the plants were not present.

No rare flora should be disturbed in the construction and maintenance of firebreaks. To achieve this, botanical surveys for the occurrence of rare flora along proposed firebreak lines should be carried out. Where species of rare flora are known to colonise disturbed soils, such as *Dodonaea hackettiana, Acacia depressa* and *Banksia brownii* and *B. goodii*, surveys of the firebreaks in such areas as these species occur should be carried out.

Rare Fauna

The protection of rare fauna involves the protection of the life of the animal and its habitat. Firebreaks are constructed to protect the habitat from the degenerating effects of too frequent fire and, in some instances, to allow for the safe manipulation of the habitat by the use of fire as a biological tool. It should be the policy of firebreak design to disturb as little as possible of the feeding and breeding habitats of the rare fauna once these have been identified. Habitat identification will require consultation with research staff conversant with the needs of the fauna concerned. The placement of firebreaks may occupy larger areas of other habitat types than would be the case if the rare fauna was not present.

Fig. 2. The edge of a firebreak being colonised by *Banksia goodii*, a species of rare flora. Care should be taken during maintenance to avoid disturbing such plants.

Key Site

Where a nature reserve has been given "Key site" status, the nature conservation values of the reserve have been considered to represent a particular type of habitat in a well preserved state. More extensive firebreak systems may be required to maintain the high conservation values of these reserves.

Research Areas

Where particular nature reserves are being used for scientific research, particularly in relation to fire ecology studies, firebreak design should be arranged in consultation with the research team. In a fire ecology study the research team may desire to maintain an area of bush land free from fire for a considerable time. This may require a more extensive system of firebreaks than might otherwise be the case in a non research area of the same type of vegetation.

Restricted Habitat Type

Where there is a restricted habitat type on a nature reserve the extent of disruption to it should be minimised if it is not possible to avoid all disruption. The occurrence on a nature reserve of habitat types, and plant species at the edge of their range, may require that these areas be treated as restricted habitat types. The fewer examples of these habitats being preserved on nature reserves the greater the need to protect them. Firebreak systems may reflect this in the total area of the reserve committed to wildfire control.

Reserve Class

The Department of Lands and Surveys has three classifications of reserves, Classes A, B and C. A nature reserve is given a Class code upon the request of the Western Australian Wildlife Authority when it is gazetted and vested. Any Class A reserve is considered to have greater conservation values than a Class C reserve.

The Class of reserves can be used as an initial indicator in grading conservation values. On Class A reserves more extensive firebreak systems to protect the higher conservation values of the area are more readily justified than on Class C reserves.

Reserve Size

The size of a reserve influences the design of firebreak systems most dramatically in relation to the width of the breaks, and the number of compartments the area can be divided into. This relationship is best demonstrated when the general formula for the area of the perimeter firebreaks as a percentage of the total area is plotted against the total area. This was done for three basic reserve shapes: squares, rectangles, and isosceles triangles. The graph below demonstrates the relationship.

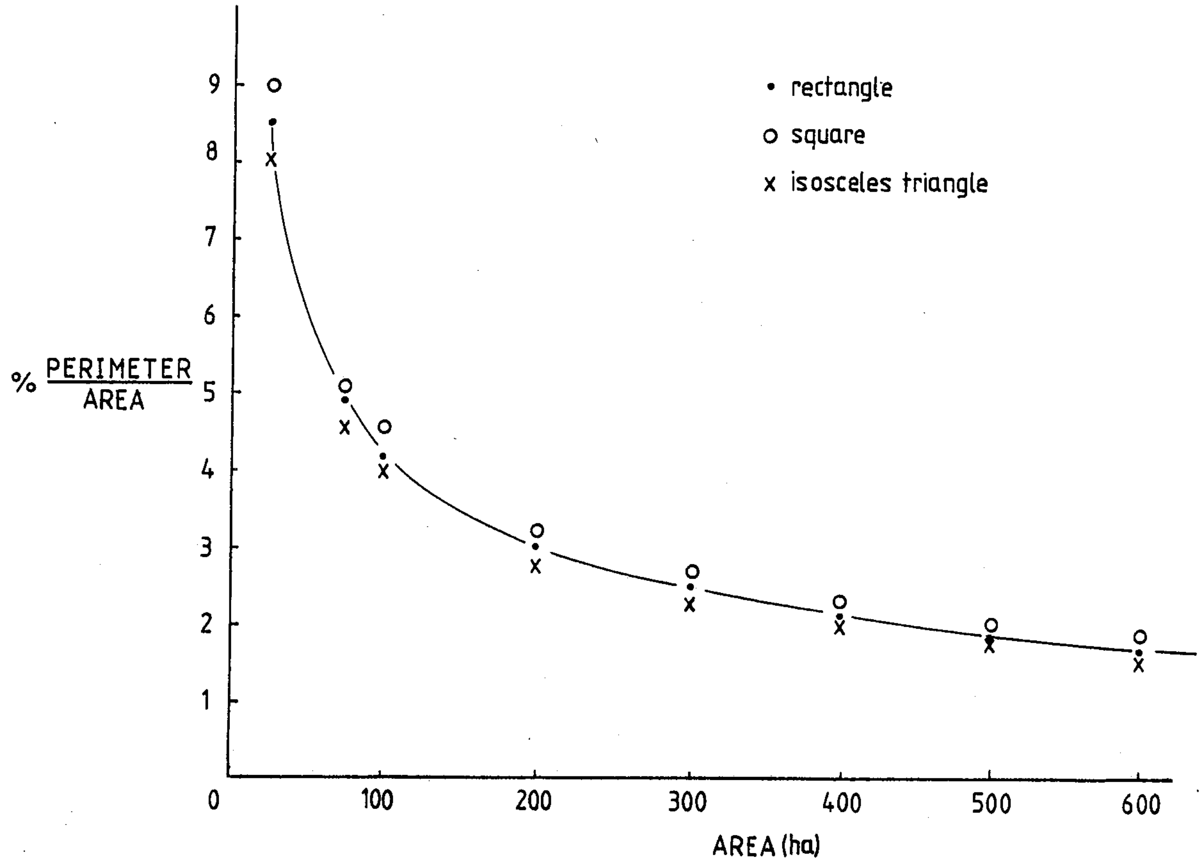

Fig. 3. The graph plots the general relationship between the percentage area of a reserve lost in firebreaks and the total area of the reserve.

Two significant figures can be identified from this graph. When a reserve area becomes less than 100 ha, the percentage area taken up in firebreaks increases dramatically.

From this generalised graph the figure of 2% of the total area of a reserve is proposed as the maximum area to be disturbed by firebreak construction. This figure includes the areas affected by both perimeter and internal firebreaks.

As the perimeter of a reserve is fixed, the width of the break can vary so that the total area does not exceed the 2% limit. For a 100 ha rectangular reserve, the maximum perimeter firebreak width would be 4.7 m, while for a 10 000 ha rectangular reserve the maximum perimeter width firebreak would be 47 m.

Large reserves need to be divided into compartments to reduce the possibility of the whole reserve being burnt out at the one time, and to make wildfire control easier. The general considerations of the loss of perimeter area to firebreaks suggest the minimum compartment size of 100 ha. It is also thought that reserves and compartments of less than 100 ha would be burnt out completely in a wildfire. The resultant damage from herbivores grazing regenerating vegetation becomes increasingly severe as the area burnt is reduced. There is only limited data available on the area size which can support herbivores grazing regrowth without causing damage to the conservation values of the area through the loss of plant species. For these reasons the conservative figure of 100 ha as minimum compartment size is proposed.

It is not practical to try to establish 100 ha compartments on all large reserves, even if the total area committed to firebreaks is within the 2% maximum, as the total length of the firebreaks to be constructed and maintained would incur financial costs in excess of the possible benefits that might accrue to the reserve. The probability of wildfires starting on a nature reserve from lightning strike increases as the size of the reserve increases. To counter this increased fire risk, an increase in the number of compartments may be contemplated. However, this needs careful consideration as the benefits to be gained may be marginal compared to the costs involved.

Vegetation

Where vegetation types are known to be highly flammable and existing fuel loadings capable of supporting intense wildfires, the firebreaks to be used for wildfire control may need to be wider than in areas where vegetation is fire resistant with low fuel loadings.

Fuel loadings can be assessed for forest and woodland habitats by following the Forest Department tables designed for that purpose. The rate at which fuel accumulates will be primarily dependant on rainfall. The higher the rainfall the faster the plants will grow and produce fuel for fires. Nature reserves in high rainfall areas are therefore in higher fire risk areas and may need firebreaks of increased widths.

Ecotones, those boundaries between two or more vegetation associations, support greater varieties of plant species than any single association.

It is not in the best interest of a reserve's conservation values to place a firebreak along an ecotone. Should disturbance of an ecotone be unavoidable, it may be minimised by crossing it in the shortest distance.

Where a reserve is dominated by one vegetation association it may be beneficial to the conservation values of the reserve to divide it into compartments, in accordance with the 100 ha guidelines discussed above. By so doing, the maximum number of seral stages, and thus habitat diversity, may be achieved. In the event of a wildfire, or a controlled burn program in the area, not all of the dominant association will be burnt out at once. This allows for the re-population of the affected compartments from surviving fauna populations in neighbouring areas.

Areas of known fire resistant vegetation can be utilised as natural firebreaks and incorporated into firebreak systems.

ADJOINING LAND STATUS

The status of land adjoining nature reserves may be developed, developing, undeveloped, or to be developed. The extent of the firebreak system designed for any reserve may be influenced substantially by adjoining land status.

For a nature reserve that adjoins developed farmland, the risk of fire crossing into the reserve is greatly reduced. This is seen to be the case when the figures for the source of wildfires affecting reserves are analysed. The major cause of wildfires affecting reserves is escaped clearing burns. In developed farmland clearing burns are minimal, and their intensity greatly reduced. The subsequent threat from developed farmland as a potential source of fire is greatly reduced.

The opposite is true for reserves that adjoin developing farmland where the frequency and intensity of clearing burns are higher. Until such time as the frequency of clearing burns is reduced, the firebreak system on these reserves may need to be more fully developed. Where the size of the reserve allows for the development of composite firebreaks of bare earth and low fuel type, these should be considered. Once the adjoining farmland is developed and the wildfire threat decreased, the low fuel areas may be permitted to regenerate.

Adjoining land of undeveloped status may be vacant Crown land of various types, or private property yet to be developed. The present and potential use of adjoining land needs to be carefully considered. Where it is expected that vacant Crown land will be released for farming, an increased fire risk from escaped burns can be expected. The firebreak system designed for these reserves should reflect this, even before the land is released.

Where adjoining land status appears to be stable, being Crown land administered by a Government authority for a specific purpose, such as Forest areas, then the firebreak system needs to be planned with this in mind. Nature reserves that adjoin such areas form large expanses of continuous bushland and should be incorporated into strategic fire control plans for the whole area. This planning will necessarily involve a number of other Government Departments. Though the Department of Fisheries and Wildlife cooperates in these strategic fire control plans, it should remain the reserve manager's highest priority to retain optimum conservation values for any reserves included.

TOPOGRAPHY

Slopes

Hill slopes may affect firebreak design in two ways. The interaction of fire with slopes influences their placement, while the angle of the slope and problems of erosion on bare earth firebreaks affect the safe movement of fire-fighting vehicles. The general principle is to avoid all slopes, and if this is not possible to follow contours.

A wildfire spreads more rapidly and with greater intensity up slopes, while the opposite is true of fire moving down hill. To maximise the usefulness of firebreaks in all prevailing wind conditions, they should follow the ridges. In this way firefighters are not exposed to the greatest intensity of a fire as would be the case if breaks were constructed across slopes. It is felt that in this way the safety of men and equipment will be improved. By following ridges there may be fewer slopes encountered to impede safe movement and the camber on the firebreak will be less likely to tip vehicles sideways. The gradient of a firebreak may cause access problems for fully laden firefighting vehicles. In New Zealand it was recommended that only firebreaks with gradients of less than 1:6 be constructed for reasons of access and erosion. In Western Australia, particularly on sandy soils, gradients of more than 1:15 have been found to impede the safe passage of fully laden fire-fighting vehicles. It is recommended that firebreaks not be constructed on slopes with gradients of more than 1:15.

During rainfall, bare earth firebreaks act as water catchment areas, and are exposed to the effects of water erosion. These effects become greater as slopes increase. Erosion is a major threat to the overall effectiveness of firebreaks, as eroded breaks impede the safe movement of firefighting vehicles.

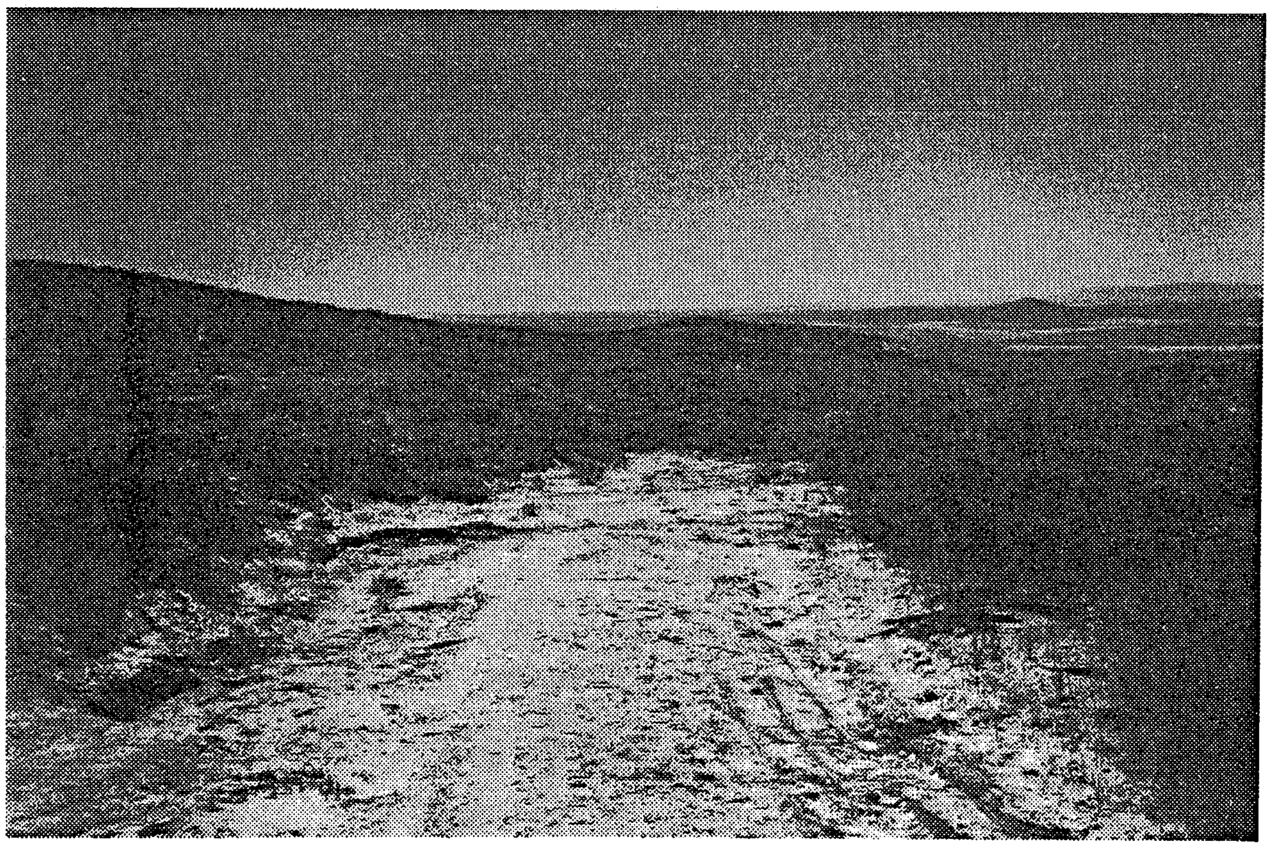

Fig. 4. The effect of water erosion on a sandy slope which was provided with water run off facilities. This same effect is seen in all soil types on slopes.

To minimise the effects of water erosion it is necessary to reduce the two major damaging factors: the total volume of water collected and the velocity of water runoff. To reduce the volume of water collected on a firebreak's surface requires that the catchment area be minimised. This may be done in one of two ways. By coming directly down a slope the total catchment area is minimised, and is considered a viable option, provided that the slope does not exceed the 1:15 gradient guideline.

The other method is to break up the total area with combinations of mounds and ditches cut at shallow angles across the line of the break at regular intervals. As the gradient of the slope increases, the distance between these water runoff structures should decrease.

Where vegetation types allow, slashed low fuel firebreaks should be considered as a viable alternative to bare earth breaks on sandy slopes. Slashed breaks have the advantage of providing more stable surfaces in sandy soils. This advantage needs to be weighed against the inability of slashed breaks to halt fires, and the increased costs of maintenance.

Breakaways

Breakaways have at times acted as low fuel firebreaks. There appear to be advantages to be gained if breakaways are incorporated in overall firebreak design. It is possible to increase the effectiveness of the overall break system by placing a firebreak on level ground behind and parallel to the line of a breakaway. The overall width of the firebreak will have increased with no extra loss of area. Breakaways do pose problems when attempts are made to cross the line of the breakaway. Gradients are too steep in these sites and should be avoided.

Water Courses

Water courses on nature reserves can act as natural firebreaks, as examination of aerial photography easily verifies. Wildfire scars often halt abruptly along the line of water courses. The higher moisture content of the vegetation reduces the intensity of the blaze and in favourable conditions may halt a fire. As natural firebreaks water courses should be incorporated where possible into firebreak designs.

There are however some limiting factors in the use of water courses. Where a firebreak crosses a stream access problems arise. Culverts may need to be installed to ensure the ability of firefighting units to cross the stream. Culvert installation increases construction and maintenance expenditure. As such it becomes a limiting factor. Where possible it seems advisable to avoid stream and creek crossings.

Lakes and swamps constitute a different problem. Water from these areas may spread along any nearby firebreaks making them impassable to maintenance and fire-fighting vehicles during the early months of the fire season. They are also exposed to greater erosion as water flows along the firebreaks. Firebreaks should not be placed so that they come to a lake shore or through the perimeter of lakes and swamps for these reasons. To avoid perimeter areas of lakes aerial photography should be used to identify maximum winter areas of lakes and swamps. In general, firebreaks should be constructed to provide two way access at all times. In the event of a wildfire cutting safe access in one direction, fire-fighters can escape danger in the other. A firebreak that ends abruptly at a lake shore or in a swamp does not provide safe two way access.

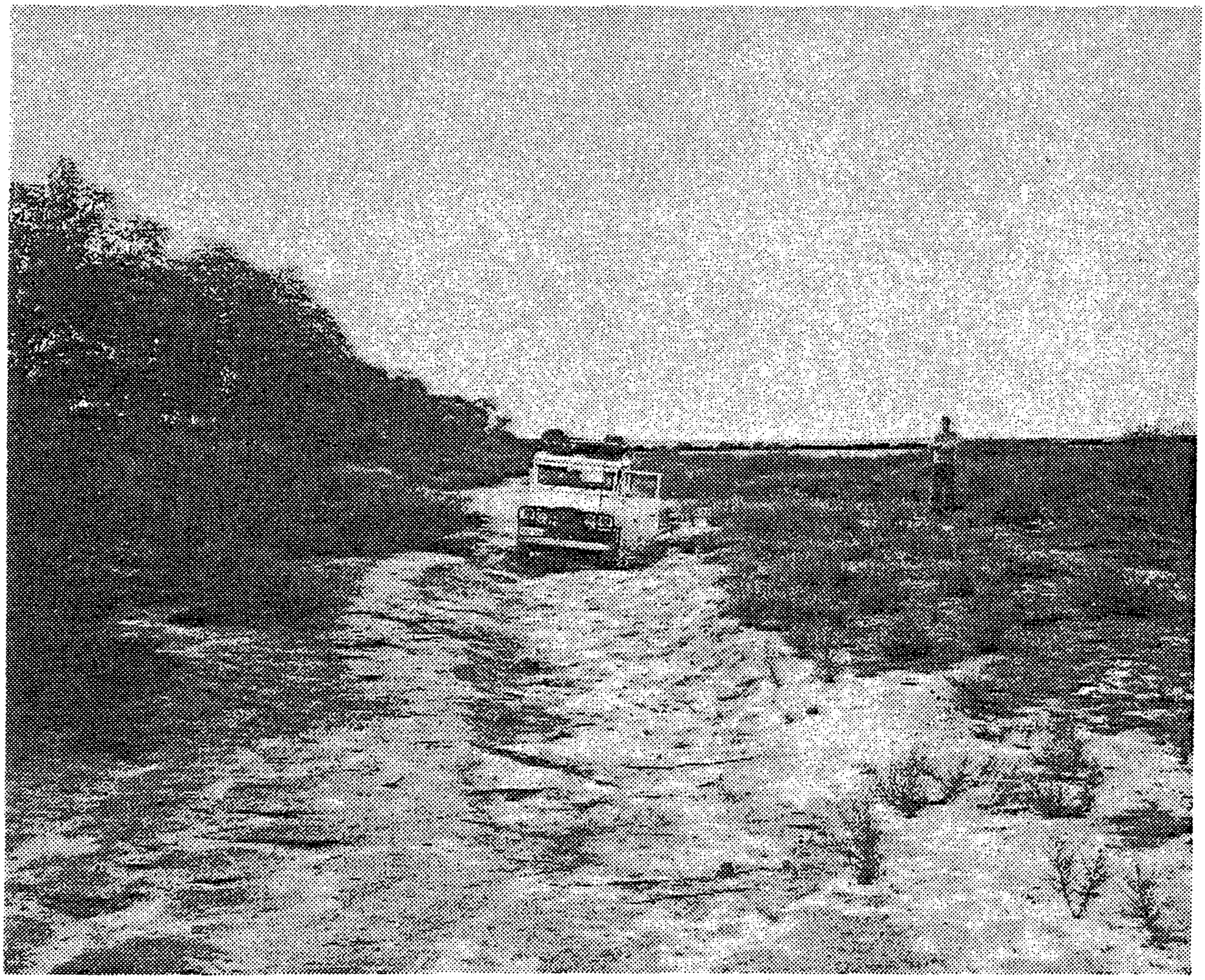

Fig. 5. Placement of this firebreak caused it to become a creek during winter. Though not yet impassable, erosion is quite severe.

It is proposed to treat water courses in the same manner as breakaways, by complementing these natural firebreaks with man-made ones.

Lithic Complexes

Lithic complexes have very fragile low fuel ecosystems which are easily damaged by the movement of vehicles. However, they are extremely effective low fuel firebreaks and when incorporated into firebreak designs may greatly improve the effectiveness of the system. The fragile nature of lithic ecosystems and the narrow ecotones bordering them should be disturbed as little as possible while incorporating such complexes into the overall firebreak system. To achieve this it is proposed that firebreaks stop short of lithic ecotones. The area between the lithic complex and the termination of the firebreak will usually be low in fuels and easily crossed by vehicles. Vehicular movement across lithic complexes should be kept to a minimum.

Sand Dunes

Sand dunes have ecosystems equally as fragile as lithic complexes. Their very unstable deep sands, which are highly susceptible to erosion by wind and water, are an added problem for the construction of bare earth firebreaks. As sand dunes are mostly in coastal areas subject to high winds and rainfall, erosion becomes a major problem for bare earth firebreaks. Erosion due to summer rainfall is particularly severe. During summer, rain collected on the firebreak surface is not absorbed. Instead it runs off causing deep scouring leaving gullies which may be impassable to firefighting vehicles. Firebreaks on sand dunes are noted to provide safe access for only a limited time to fire-fighting vehicles. Firebreaks on which vehicles become immobilised are no longer benefits, as they may become tragic liabilities.

Slashed low fuel firebreaks are considered to offer safer access for a longer time by leaving the soil surface undisturbed. However, these breaks can only support limited vehicular traffic before they too become dangerous.

In general, it seems advisable to avoid constructing firebreaks on sand dunes.

Cap Rock

The construction and maintenance of firebreaks through cap rock terrain has special problems. In these areas the construction of bare earth breaks may require a bulldozer. The use of such a machine disturbs the sub-soil and may bring to the surface increased amounts of stone rubble making movement along the break hazardous. This may be unavoidable. Traditional methods of maintenance, such as ploughing and grading, may aggravate the problem by bringing to the surface more stone rubble. The stone rubble littering the break's surface is considered to be potentially damaging to farm machinery used to maintain it.

Alternative means of maintenance should be sought. One option worthy of further investigation is the use of non-residual herbicides to control regrowth. The use of a commercial brand, "Round-up", is presently being tested in the Pingelly Management District with up to 70% kill on first application. Over a period of two to three years the regrowth should be controlled. The advantage of this method is that the sub-soil remains undisturbed, and the problem of bringing new stone rubble to the surface is reduced. Before this method of maintenance is initiated, the surface of the firebreak should be cleared of all large obstacles that could hinder or make dangerous the movement of fire-fighting vehicles and farm machines. This should be done during construction, which makes these breaks more expensive in financial terms. It is more beneficial to bear these increased construction costs than to find a firebreak made ineffective due to lack of maintenance because of the damage to maintenance vehicles from a rough surface.

At the time of planning the firebreak system, the availability of herbicide spraying or wick applicator equipment should be ascertained to ensure that maintenance can begin upon completion of construction.

BOUNDARY ROADS

Formed roads that follow nature reserve boundaries may be both beneficial and detrimental at the same time to preservation of conservation values. These roads can act as firebreaks of superior quality in terms of access for fire-fighting units due to their more stable surface. They may also be wider than other breaks in the area. The width of formed roads, when added to any existing firebreaks, will increase the reserve's protection from invading wildfires, and surrounding property from wildfires that might escape reserves. Where reserves have roads bordering them the risk of fire starting on them from human causes such as discarded cigarettes and matches or escaped camp fires may increase. The potential threat from fire varies with the amount of public use of the road. Firebreak systems should be designed to reduce increased fire risk.

Bare earth firebreaks may be constructed on reserves parallel to roadways. There is some debate as to whether bare earth breaks should abut roads, or a strip of vegetation, acting as a low fuel break, be left between the road and the bare earth break. Low fuel breaks are not proposed simply for aesthetic reasons, as they have advantages in terms of reducing the ingress of wind borne weed and grass seeds, soil and fertilizers from neighbouring farmland. However, they require control burning to reduce fuels. Risk of fire affecting more of the reserve increases where control burning takes place on a reserve reducing the benefits of burnt low fuel breaks. Increased financial costs are incurred from man hours required to carry out control burning. The effect of frequent burning is to open the understorey of vegetation associations. Where these low fuel breaks trap soil, fertilizer and grass seeds, they allow grasses and noxious weeds to establish themselves more easily, and may increase the fuel loadings and the ease of ignition. These situations may aggravate the fire hazard. For these reasons it is considered more beneficial to construct bare earth firebreaks abutting bordering roads where neighbouring land is developed farmland. Where neighbouring land is developing and the problems of weed invasion are reduced, it may be advisable to use a combination of bare earth and low fuel firebreaks. This may particularly be the case where it is desired to reduce public vehicular access to reserves, in which case the low fuel break can be used to screen the existence of the bare earth break.

ROADS THROUGH RESERVES

Roads and tracks that pass through reserves may be considered to provide adequate firebreak facilities. Heavy public use of such roads and tracks may require additional firebreaks parallel to them to offset the increased fire threat. Where additional breaks are considered necessary, the maximum width of the break should be sought. This may be achieved by leaving a strip of vegetation between the road and parallel bare earth break. This strip of vegetation acts, not only as a low fuel break, but also as a screen to the existence of bare earth breaks, hopefully reducing vehicular access to the reserve and possible degradation of its conservation values. Care should be taken to disguise the entrance to the bare earth firebreaks.

As all adjoining land to a road through a reserve will be bushland, no major increase to the fire hazard of the vegetation buffer strip from weed invasion is likely. In this situation the combination of bare earth firebreak and vegetation buffer strip is considered as beneficial to the reserve.

SOIL TYPES

The type of firebreak, its method of construction and maintenance may be influenced by the soil type on which it is to be established. This is so primarily because of erosion problems of some soils, particularly sands.

Sands

Firebreaks on sands are susceptible to erosion by both wind and water, an effect that is increased when on a slope. Erosion, slope and the depth of sand combine to make access along such firebreaks a major concern. The type of firebreak constructed on sandy soils should not only act as a barrier to fire spread, but also provide safe access to firefighters and their vehicles.

To achieve this aim it may be necessary to compromise the ideal of a totally bare earth firebreak. By installing slashed low fuel firebreaks in heath vegetation root systems can be retained in the soil to bind it together, providing safer access. In other vegetation types where the removal of trees is necessary, the method of maintenance may need to be varied so that maximum stability of the surface is maintained. This may mean that after the initial ploughing or raking, herbicides be used to control regrowth. In this way some of the root system of the vegetation can be retained, helping to stabilize the soil surface.

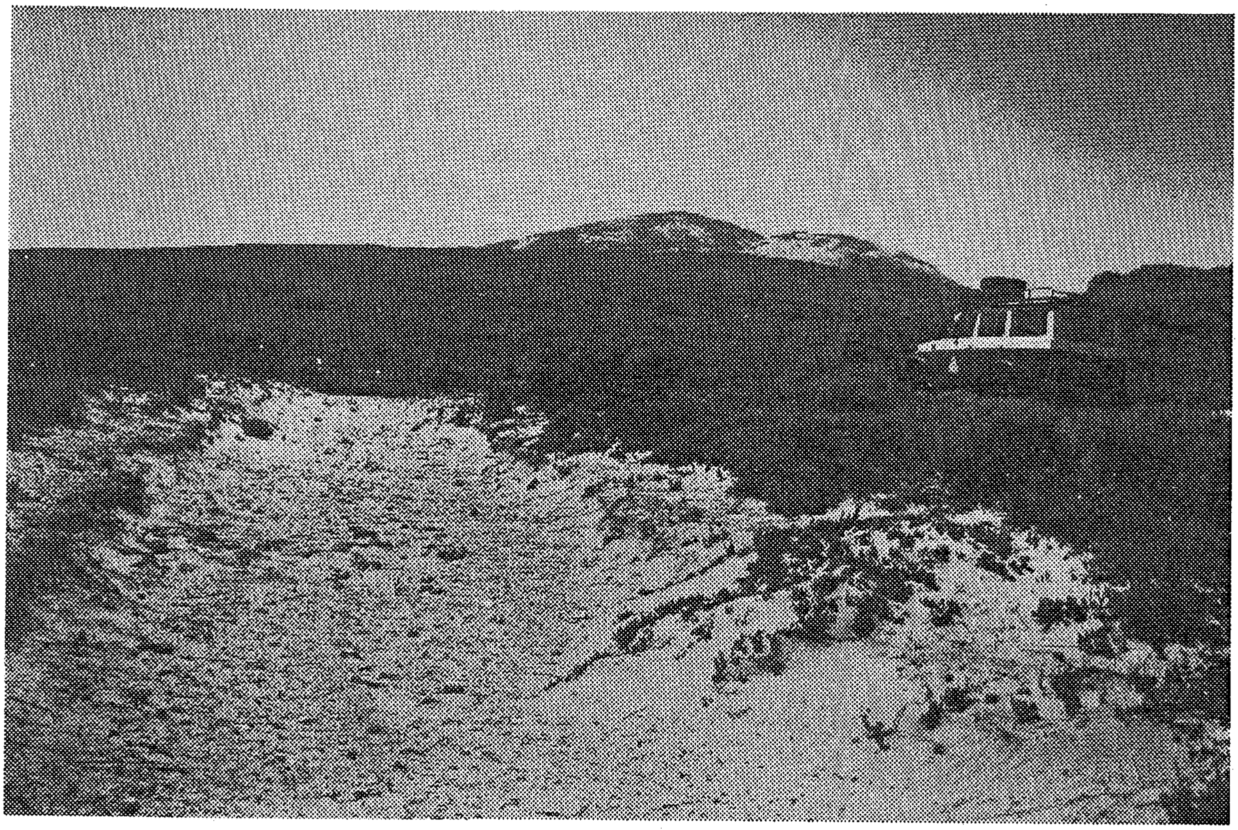

Fig. 6. The effect of wind and water erosion on sandy soils. The vegetation on the side of the firebreak has been partly covered by wind borne sand. The channeling effect of the wind has aggravated the water erosion problems.

Loams

Other soil types such as loams and sandy loams are prone to the same erosion problems as sands, though they are not usually accompanied by the deep sands which, when ploughed frequently, can become loose and a hazard to vehicles. Loams and sandy loams need the same consideration as sands.

Cap Rock

The complexities of firebreaks on cap rock terrain have been discussed above and need not be repeated.

Clays

Clay and clay combination soils, when dry, provide very stable surfaces for bare earth firebreaks. However, there are problems of access along them in winter and spring when maintenance is usually carried out. These problems may be extended into the early days of the fire season when the placement of firebreaks exposes them to the effect of water for long periods, slowing the drying process. The implication is to keep firebreaks out of wetland areas, particularly if reserves are considered to be at high risk in the early days of the fire season.

The "Lake Muir wetland system" demonstrates these problems of placement, maintenance and access in the early fire season, though not in clay soils.

Laterites

Laterite soils with a clay component are considered perhaps the most stable soil on which to construct bare earth firebreaks. They are less prone to erosion by wind and water, less of a problem in terms of maintenance and access due to moisture retention. Like all soils, the introduction of slopes increase erosion problems and require attention. These problems have been discussed under the heading Slopes.

CLIMATIC CONDITIONS

Climatic conditions affect firebreak design by increasing and decreasing fire risk and intensity under different circumstances. Such conditions as prevailing winds during the fire season, rainfall, temperature, humidity and occurrence of thunderstorms are considered below.

Prevailing Winds

Prevailing wind speed and direction during the fire season may greatly affect firebreak design. Where frequent high winds from a known direction are expected during the worst of the fire season, firebreaks may need to be widened to counter the expected greater intensity of wildfires fanned by these winds.

The method of fire attack can be facilitated by the placement of firebreaks. Knowledge of the prevailing wind direction, obtainable from Bureau of Meteorology data, during the fire season will allow the placement of firebreaks at an angle to the prevailing wind and facilitate the use of preferred flank attack methods. The effectiveness of the firebreak will also increase as the distance that flame and heat radiation have to cross as the angle is maximised.

As prevailing winds of greatest velocity during the fire season are in the main from either the north-west or south-west, firebreaks in a north-south alignment will provide the desired flank attack facility, while allowing the added advantage on reserves of fire crews being able to easily identify their position and the direction of fire spread.

These conditions apply more to internal firebreaks where there is greater flexibility in placement.

Rainfall

Generally firebreak design requires estimates of fuel loadings, rates of growth and fuel accumulation, which may influence firebreak widths. These figures may be obtained by sampling vegetation sites after Forest Department procedure. Rainfall affects fuel loadings. Vegetation associations in high rainfall areas have faster growth rates, and hence, heavier fuel loadings and fuel accumulation rates over a given period. After any fire, vegetation in these areas will more quickly reach the level of fuels that existed prior to the fire than in lower rainfall areas.

High fuel loadings result in more intensive wildfires, while faster fuel accumulation rates will result in more frequent high intensity wildfires. Firebreaks in high rainfall areas should be designed to counter these increases in fire risk by increasing their widths. This is particularly so for perimeter firebreaks.

Temperature

The expected range of maximum and minimum temperatures will affect the fire risk. In areas of very high temperatures over extended periods of time the fire danger will become extreme and rates of spread very fast. The time over which a fire will burn with maximum intensity may also be lengthened. The amount of time available to firefighters to reach wildfires before they reach extreme proportions is greatly reduced in these situations.

To reduce the damage to nature reserve habitats fire control measures may need to be intensified by increasing the number of compartments in large bushland areas providing more opportunity to slow a fire's rate of spread and gain time for firefighters to reach the fire. This is only a consideration for very large reserves. It may well be found to be impractical to install large numbers of compartments. The benefits in terms of time gained may be minimal when the increased costs of fire-break contruction and maintenance, and the availability of heavy equipment in the near vicinity of a reserve that can be called on to quickly install temporary firebreaks to stop specific fires, are considered.

In coastal regions where it is known that a fall in the temperature can be expected in the afternoon the placement of firebreaks may be affected. This is particularly so in areas that have a fire history which identifies certain points as ignition sites at a particular time of day. By estimating the rate of spread, it may be predicted where the fire will have reached by the time the drop in temperature is expected, and the intensity of the fire will have appreciably fallen. A firebreak may then be constructed in the projected area, making use of any natural firebreaks and other information such as expected wind changes and vegetation types. In this way the efficiency of the firebreak will be maximized, as can available man power for suppression of the blaze.

Humidity

Humidity can affect the placement of firebreaks in the same way as temperature, where changes in humidity can be anticipated in the afternoon. Increased humidity brings an increase in the moisture content of the air and fuels. Higher moisture content in fuels will reduce a fire's intensity and rate of spread. In coastal regions the fall of temperature is usually accompanied by a rise in humidity which will aid firefighters in suppressing wildfires. The placement of firebreaks will be affected in the same way as when utilising falls in temperature.

Thunderstorms

Lightning strike is the source of up to 7% of wildfire ignition in forests. Lightning strikes from dry summer thunderstorms may be more of a threat to nature reserves than winter storms. If a nature reserve is considered to lie in an area of potentially higher fire risk due to the occurrence of summer thunderstorms, fire protection measures may need to be increased.

From Bureau of Meteorology data the area most prone to summer thunderstorms is the eastern fringe of the wheat belt and the mallee country north of Esperance. Nature reserves in this marginal farming area of mallee country are substantially larger in comparison with the more established farming areas. These larger reserves will support wider firebreaks without exceeding the proposed 2% area allowance. The full amount of the allowable area should be used in these high risk nature reserves in the construction of perimeter and internal breaks maximising the number of compartments where possible. Financial cost should not be overlooked and the need to balance benefits and costs as always needs careful consideration.

PREVIOUS FIRE HISTORY

A knowledge of the fire history of an area is particularly valuable in designing firebreak systems. This information can be obtained from a variety of sources.

Sources

The most important source is reports of fires on, or threatening, nature reserves, which should be kept on the individual reserve file. A copy of individual fire reports should be kept together on a file for any one fire season. Reports should include information on the date, source, area affected, men and machinery used to suppress the fire, any extra costs through the hire of machinery to cut temporary firebreaks, climatic conditions at the start of the fire if known, and the time it burnt.

Other sources include aerial photography and Landsat imagery. From these sources past ignition points and entry points can be identified, as well as wind directions, some indication of wildfire intensity, rate of spread and the amount of damage done to the reserve.

When this information has been gathered it is possible to develop a firebreak system that will maximise the protection of the reserve's conservation values.

Where a specific point or area has been identified as the site of numerous fires starting or crossing into reserves, such as picnic areas or fishermen's camps, wider breaks can be constructed to minimise the threat of fire to the reserve from the area.

Natural firebreaks, which in the past have effectively stopped wildfires, can be identified from aerial photography and Landsat imagery. Where possible, these features should be incorporated into firebreak design. Fuel loadings of previously burnt areas can be estimated from aerial photography and the identified fuel mosaics and seral stages incorporated into firebreak systems when the large areas of bushland are divided into compartments by internal firebreaks. These estimates need to be checked on the ground before the firebreaks are constructed.

The importance of keeping detailed records of fire histories can not be too strongly stressed.

REQUESTS FOR FIREBREAKS

Periodically requests for firebreak construction on nature reserves will be received from reserve neighbours, Local Government authorities or other Government departments. These requests are not to be ignored, nor should they force the construction of firebreaks without due consideration. Past experience has demonstrated that this course of action does not always provide for the best protection of the reserve's conservation values, nor use of funds, as work may need to be re-done if the firebreak system installed is seen not to provide the protection it should when tested in a wildfire situation.

Through consultation with the person or organisation making the request, their expectations can be ascertained enabling the firebreak system designed to give greatest satisfaction to their desires. However, throughout these discussions maximising the conservation values of the reserve should always be the highest priority. This does not imply that there is no room for negotiation. The majority of requests will probably be for the construction of perimeter breaks to protect adjoining farm property. Negotiations will probably center on the width of the break. It should be possible to satisfy the requests of reserve neighbours in this regard without committing more than the recommended 2% of reserve area.

Where the conservation values of the reserve are seen to require more than just perimter breaks a complete design should be completed before any construction work begins. If it is considered that perimeter breaks are sufficient protection for the reserve, the design and construction of the system should be completed as speedily as possible.

The priority of construction work may well be altered when a request for firebreak construction is received. However, it does not seem reasonable to allow political pressure to drastically alter priorities, as would be the case if a small wheat belt reserve surrounded by cleared firebreaked farmland were to be breaked before a larger "key site" reserve.

DIEBACK

A paper on this critical issue outlining the policy of the Department of Fisheries and Wildlife is currently being prepared. With regard to the construction and maintenance of firebreaks the policy should be to avoid any area known or even suspected of contamination.

In the course of surveying the proposed route of a firebreak, attention should be given to the condition of known susceptible plant species such as Banksias and Eucalypts. Where an area is suspected of contamination, soil and root samples of affected vegetation should be taken and submitted for analysis. Should the tests produce positive results, the proposed route should be immediately changed and the new route surveyed.

Construction and maintenance vehicles that have been known to come from dieback affected areas should comply with hygiene requirements as laid down in the Department's dieback paper.

PUBLIC USE

Where it is known that the public utilise a particular section of a nature reserve for activities such as picnics and camp fires, then provision can be made to increase the protection of the reserve in that area by widening the firebreaks.

The proximity of nature reserves to centres of population may increase fire risks on them simply by the greater opportunity for illegal fires to be lit on reserves.

Construction of firebreaks may expose greater areas of reserves to the activities of horse riders, trail bikes and four wheel drive vehicles, which may be detrimental to the conservation values of reserves. This does not mean that firebreaks should not be constructed, rather that care should be taken in the planning stages to conceal the entrances to firebreaks where it is considered necessary, and to make access to conventional vehicles difficult.

Access

Where possible, existing roadways and farm tracks should be used as primary access routes to firebreaks. This may require the construction of gates in existing fence-lines, or the re-alignment of a firebreak so as to use an existing gate. As efforts may have been made to conceal firebreak entrances from public roadways, maps of reserves showing these features need to be made to aid firefighters seeking to gain access.

Concealing Entrances

Methods of concealing the entrances to firebreaks may take a number of forms. Concealment should not be so complete that it would hinder the access of firefighters desiring to use the break to fight fires.

The initial stages of a firebreak may be taken off at an angle to the line of access by which the public approach the reserve, and the presence of the firebreak concealed behind a strip of vegetation. This method can be varied by using a track through the strip of vegetation. The only visible sign of the firebreak will be the wheel tracks leading through the vegetation.

Difficult Access

Making access difficult should not inhibit the movement of firefighting vehicles. The aim is simply to limit the access of conventional vehicles that might be used for activities that might be detrimental to the reserve.

Access to firebreaks can be hindered through the use of signs or in conjunction with closing the entrance with fallen timber. It may also be possible to place the entrance of a firebreak on the raised area of ground that lines the side of roadways, making it difficult to move from the roadway to the firebreak.

These techniques to restrict access need to be accompanied by public education as to the purposes of nature reserves, and by patrols of the area by Wildlife Officers to deter the public from activities which may be detrimental to the conservation values of the reserve.

MAINTENANCE CONSIDERATIONS

When planning a firebreak system, careful consideration must be given to its maintenance once constructed. It is a waste of manpower, finance and reserve values if, on completion of construction, no maintenance is carried out. The type and availability of maintenance machinery needs to be kept in mind. As most firebreaks are maintained under contract by neighbouring farmers, it must first be ascertained whether they have the machinery needed to carry out the required maintenance.

Firebreaks must be wide enough to allow access to farm machines planned to be used in maintenance.

In the more marginal agricultural areas where large acre farming predominates, machinery used to farm this land is also very large, and may require a minimum 6 m wide firebreak. Fortunately the nature reserves in the area are also large and should be able to satisfy this requirement without exceeding the 2% area limit. In areas where farm paddock sizes and machinery are smaller, the width of firebreaks can be decreased if it is considered that they still adequately protect reserve conservation values. These breaks may be as narrow as 3 m wide, but wherever possible a minimum of 4 m should be sought. The areas of the state where this reduction in size can be expected are the longer established wheatbelt areas and the moister dairy farming areas.

RATES OF HIRE

Rates for the hire of various types of machinery used in the construction and maintenance states should be set at the commencement of each year. These rates may be in line with those recommended by the Department of Agriculture or with some recognised farmer organization such as Western Farmers and Graziers. In this way the rates used in contracting construction and maintenance work will, hopefully, be equitable to all parties involved.

PLACEMENT OF FIREBREAKS

Firebreaks can be placed either as perimeter firebreaks or as internal breaks.

Perimeter

The status of neighbouring land influences the risk of fire entering a nature reserve. Where fire risks are high the perimeter break widths may need to be increased to counter it. There are a variety of options available to maximise perimeter break widths and to maintain maximum conservation values. Where a nature reserve adjoins fenced developed farmland, protection of fencelines should be high on the list of priorities. To protect fencelines a bare earth firebreak which comes as close to the fenceline as possible is recommended. The width of the break will be controlled by the 2% area figure unless internal breaks are also planned. It may be desired to have a part of the total area of the break as a low fuel break acting as a barrier to wind borne soil, fertilizer and seed. In this way the invasion of the reserve by weeds and noxious plants will be slowed.

It is recommended that this low fuel area be between two bare earth breaks, as it is not advisable to have vegetation abutting fencelines. The width of any firebreak abutting fencelines must be sufficient to allow access of maintenance vehicles. As ploughs cannot clear vegetation from beneath a fenceline it may be advisable to control all regrowth by the use of herbicides. Damage to the vegetation of the body of the reserve could be affected by wind borne herbicide. Where a low fuel buffer strip is being used, it will also act as a shield to the effects of herbicides.

Some firebreaks in the past were constructed leaving the larger trees on the line of the break. It is felt that these trees may prove to be more of a problem than a benefit to the reserve, as in wildfire situations they may act as ignition points for firebrands which may be carried into the reserve. They may also be blown down in high winds and damage fencelines. Their removal is therefore recommended.

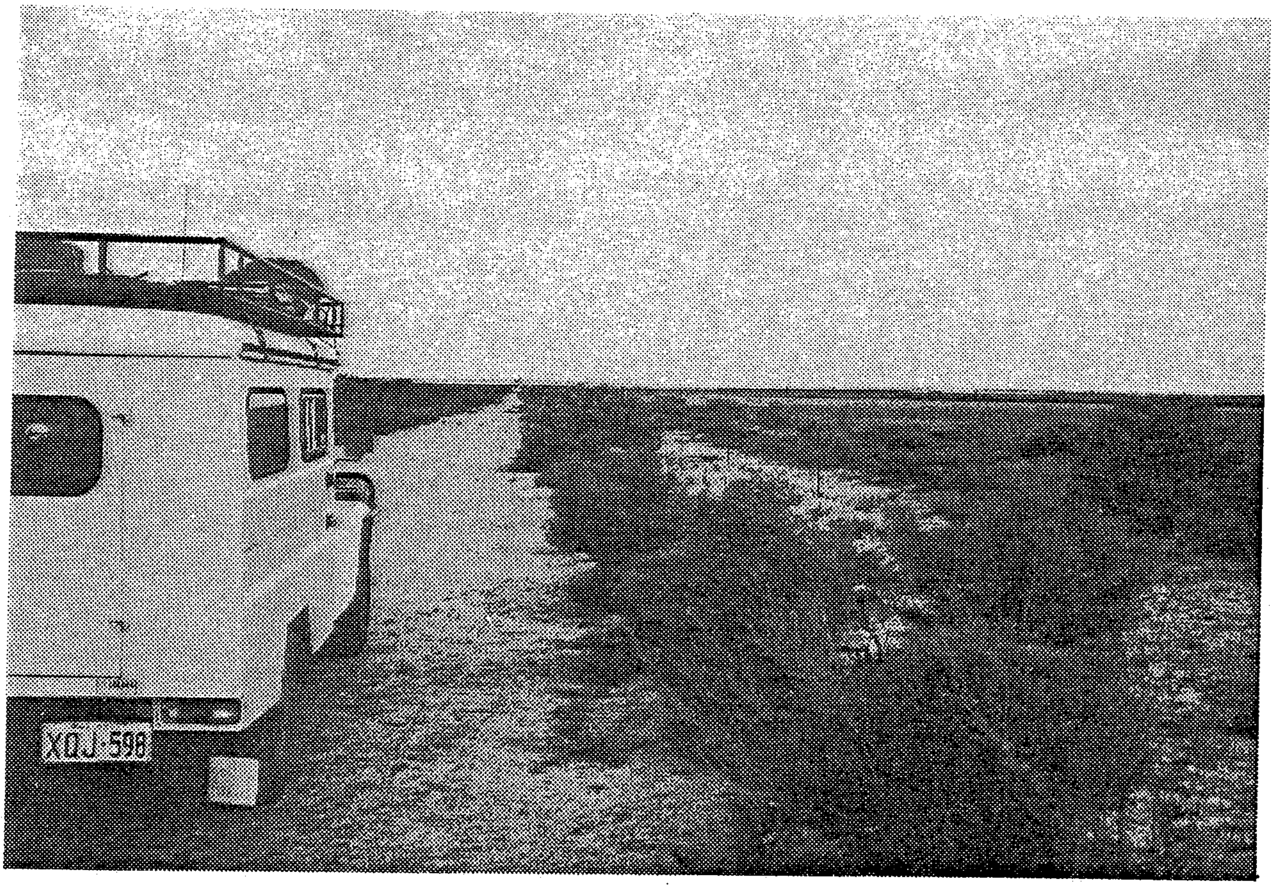

Fig. 7. The effect of a thin strip of vegetation shielding the body of the reserve from weed invasion.

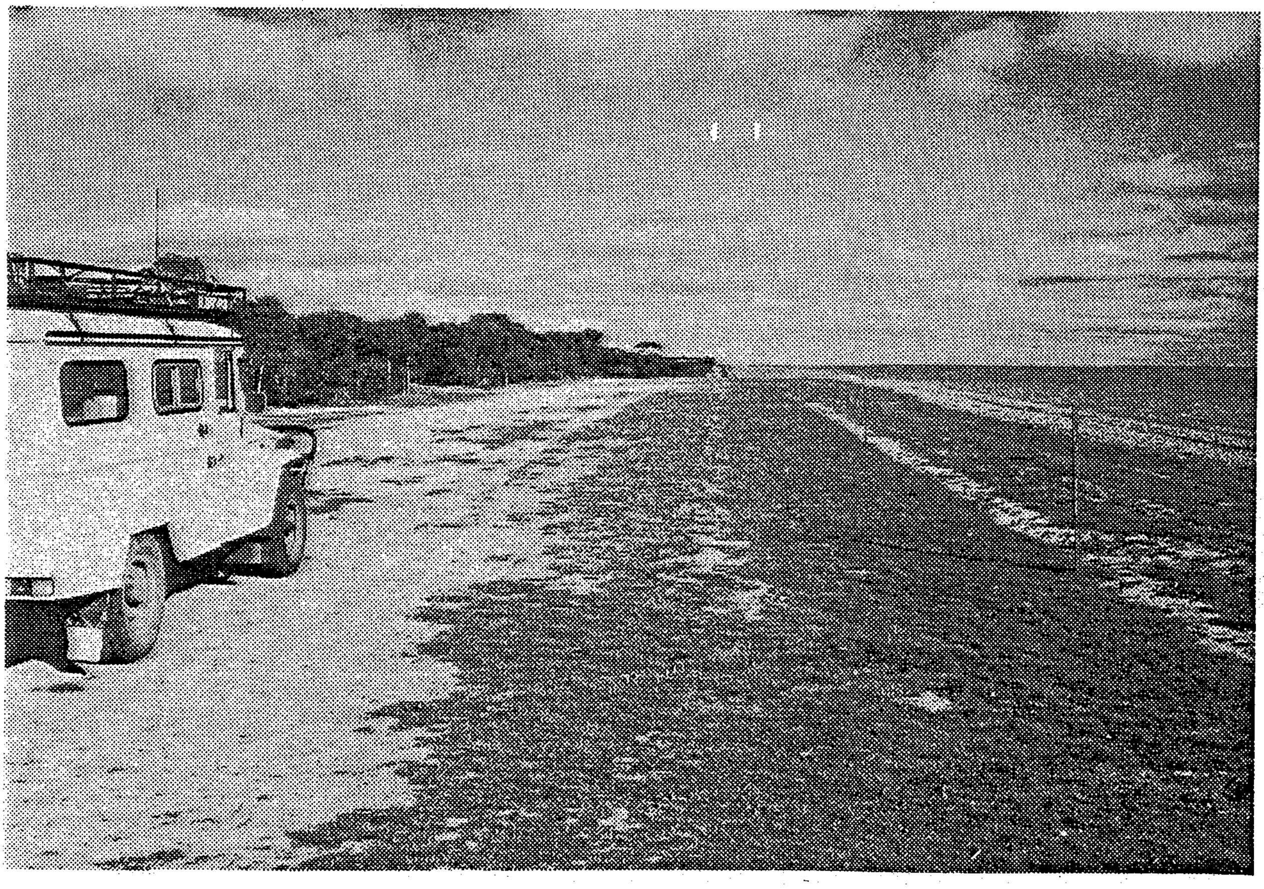

Fig. 8. On the same reserve the impact of weed invasion is quite marked where there was no intervening vegetation.

Where nature reserves adjoin vacant Crown land or undeveloped private land in a continuous expanse, the boundary of the reserve may be defined by the construction of the perimeter break. To do this effectively the boundary of the reserve must be known exactly, saving any possible extra expense that might be incurred if the firebreak needs to be re-aligned at some later date.

If the boundary of the reserve cannot be definitely identified, then it is advisable to have the boundary surveyed. In this way an up to date plan of the reserve boundary can be obtained and used to plot the constructed firebreaks.

The boundary of a nature reserve should be followed as closely as possible so that the reserve can be clearly defined. This will aid identification of the reserve for researchers and enforcement officers. The boundary of a reserve should not be deviated from except where topographical features make it necessary.

<u>Internal</u>

The placement of internal firebreaks is more flexible and can maximise conservation values by using topographic features of reserves; compartmentalization for seral stage and fuel loading mosaics to gain time by slowing the rate of spread; alignment to allow flanking of wildfires; the avoidance of ecotones; and the use of existing tracks in the area. These factors have been discussed above. It needs to be pointed out that the total area of internal breaks is included with perimeter breaks in the recommended 2% of the total reserve area. The effect of this is to reduce the maximum width of internal breaks. Perimeter breaks should have greater width than internal breaks as they are a first line against the invasion of reserves by wildfires and need to provide maximum protection.

Where internal breaks allow access and safe back-burning they are performing the functions required of them.

Where possible slashed low fuel and bare earth firebreaks should be used together to maximise the effectiveness of internal breaks, particularly in heath vegetation on sandy soils. Periodically burnt low fuel firebreaks may not be advisable in any but the most valuable conservation areas. They are more expensive to maintain and pose a higher fire risk on reserves from escaped control burns.

Internal bare earth breaks may require less frequent maintenance once they have been established. It has been found that, once the major lignotuber regrowth has been controlled, by leaving the surface of sandy firebreaks undisturbed for a number of years, a surface crust forms which reduces water and wind erosion. This firmer surface provides safer access to vehicles.

The advantages gained from this maintenance method may outweigh any disadvantages due to small amounts of regrowth on the firebreak.

Fig. 9. In unstable coastal sands a track may be a more viable firebreak than a bare earth break. It provides safer access and a line from which to back burn with reasonable safety.

Internal breaks may be maintained by the use of herbicides. To reduce the effect of wind borne herbicide on adjoining vegetation, it may be advisable to use a wick applicator when treating internal firebreaks. Herbicides have the advantage of reducing vegetation on the firebreak surface while retaining root systems to bind soil together providing safer access to vehicles.

In some situations, such as coastal heaths where sandy soils are very unstable, the use of vehicle tracks alone or in conjunction with slashed breaks may be considered an effective firebreak as it provides access over longer periods where bare earth breaks would quickly deteriorate. Fuel loadings in these areas are usually very high and a wildfire there would easily cross bare earth breaks. It seems advisable to provide safer access and a line to burn back from in this situation. Tracks and slashed breaks appear to provide these facilities while disturbing habitat less dramatically than bare earth breaks.

Water Points

It is desirable to plan firebreaks so that easy access to water points either on reserves or on neighbouring land is available. To enable this, farm dams, lakes, soaks and other accessible watering points should be identified in the planning stages. Where watering points occur on nature reserves, a track may be taken from a major firebreak to the watering point. The area of the watering point should be made safe by providing ample space for vehicles to turn around and clearing it of all fuels. A watering point against a lake shore could become a disaster area should men and machines be trapped there in the face of a wildfire.

However, it is felt that securing a watering point has advantages providing safety precautions are taken. These watering points and their access routes should also be shown on maps of the firebreak system.

TYPES OF FIREBREAKS

There are four types of firebreaks: natural topographical features, two man-made types, and combinations of natural and man-made. The two types of man-made firebreaks are bare earth and low fuel. Bare earth firebreaks require the removal of all vegetation from a strip of ground; low fuel firebreaks, the removal of varying amounts of vegetation which substantially reduce the fuel loadings along the break.

A variety of methods are used to construct and maintain these man-made firebreaks.

Natural firebreaks have received attention under the heading TOPOGRAPHY, as have combination firebreaks. Little further discussion of these will be required.

BARE EARTH BREAKS

A bare earth break requires the removal of all vegetation to a desired width from a strip of ground. A good firebreak of this type should remain cleared of all vegetation, debris and root material, have a stable erosion-free surface which in turn provides safe and easy access to maintenance and firefighting vehicles. Methods of construction and maintenance vary in response to vegetation type, soil type and topography that a firebreak is to pass through. A variety of equipment has been used in the past to construct and maintain bare earth breaks. The advantages and disadvantages of the various machines will be discussed below.

Bulldozers

The most frequently used machine to construct bare earth firebreaks is the bulldozer. Vegetation, soil and topography have little impact on the successful use of these machines. A caterpilla D6, or any other equivalent powered make of machine, is considered to have adequate power for firebreak construction in all but the heaviest forest areas. In forests and woodlands bulldozers are necessary to remove large standing trees. It should be noted that a bulldozer can only be fitted simultaneously with a pusher bar and 14' rake, but not a 20' rake. Rakes are preferred to blades as they remove less soil from breaks which in turn is pushed up in the heaps of vegetation removed from the break. Smaller amounts of soil in heaps makes their burning easier in the following spring. Bulldozers do disturb the soil more drastically than any other machine used in bare earth firebreak construction. This can become a problem in terms of erosion and access at a later time. In deep sands, the disturbance of the sub-soil makes the sand very loose and potentially dangerous as vehicles may become bogged easily. In cap rock terrain the disturbance of the sub-soil brings to the firebreak's surface more stone rubble which makes access difficult and may cause damage to vehicles.

Special maintenance sequences may be required for bare earth firebreaks in sand and cap rock terrain to overcome these disadvantages. There is a potential problem in using a bulldozer to construct firebreaks. A bulldozer may well be able to construct a firebreak which is inaccessible to either maintenance or firefighting vehicles. This possibility should be overcome by careful planning of all firebreak routes, and close supervision during construction ensuring the correct route is followed.

All blade machines will either leave soil mounds at the edge of a firebreak, or cut below surface level. This creates a potential for erosion by water and wind, particularly on slopes. Bulldozers may find it difficult to install drains on slopes to counter this water erosion threat, and the use of a grader may be necessary. This involves extra expense.

Bulldozers also leave a substantial amount of vegetation debris on firebreaks which may require the use of another machine to remove. This can be done in the first year of maintenance and is not a large disadvantage.

In general bulldozers are very cost efficient and the best choice for constructing bare earth firebreaks in any type of vegetation, soil or topography.

Graders and Ploughs

These two machines have some common advantages and disadvantages when used in constructing bare earth firebreaks. Their most limiting factor is their restriction to heath and coastal heath vegetation types, as neither machine has the capability of removing trees. As heath vegetation associations are predominantly on sandy soils, the use of graders and ploughs may aggravate soil erosion and access problems normal to bare earth firebreaks. This is particularly true for graders as they cut below the surface removing root systems as well as surface vegetation. Removing the root systems in sandy soils aggravates erosion problems, as does the exposure of unstable sub-soils and the channeling effect which confines water to the firebreak.

Ploughs also create a channeling effect by depositing mounds of soil at the edge of firebreaks. Graders have the advantage of being able to counter this channeling effect by installing drains at the same time as construction.

Both graders and ploughs have problems disposing of vegetation. Graders can push vegetation off to the side, but the amount of soil also pushed off is very large. Heaps with large quantities of soil in them are difficult to completely burn out. They effectively increase the fire hazard during wildfires by providing a source from which spotting can occur.

Ploughs do not remove vegetation from the break but turn it under. Debris left on the line of the break are not as great, but regrowth from root stock may be more than on breaks constructed by bulldozers or graders. Ploughs disturb soils to greater depths than graders. In deep sands this can become a distinct disadvantage as frequent ploughing can make such soils impassable to vehicles.

The greatest advantages of graders and ploughs are their ready availability and lower hire costs. The also cause less damage to adjoining vegetation than larger machines such as bulldozers.

Time of Construction

Rainfall and moisture content of soils are two factors which will affect the time firebreaks are constructed. Where soils are too moist machinery may become bogged. As the Department does not pay for time lost due to bogging, the optimum condition of the soil should be sought. It has been found that the autumn and spring are the optimum times, except in wet land areas where construction may be as late as January.

As contractors are extremely busy at these times, it is best to book work well in advance. This may be done before the completion of firebreak planning, but it is advisable to be well advanced in the planning process.

Maintenance Methods

Periodic maintenance must be carried out to keep firebreaks in good condition. A variety of machines and sequences of their use are employed to achieve this goal. Maintenance of firebreaks includes maintenance of any improvements such as water drains and culverts. Methods of maintenance depend on habitat type, regrowth levels, weed invasion, and the availability of desired machinery to do the work.

Perimeter firebreaks must be kept in the best possible condition by the removal of all vegetation and maintaining the stability of their soil surfaces. This is because perimeter breaks are the first line of defence against wildfires entering reserves, and the last line at which fires may be stopped from leaving reserves to affect neighbouring property. Where these breaks are kept at their best, the chances of their stopping a fire unaided are improved.

The major functions of internal breaks are to provide safe access and lines from which to safely back burn, not to halt wildfires. The total clearing of these breaks may at some times need to be compromised to achieve better access.

The first three years of maintenance appear to be crucial to extending the period of usefulness of a firebreak. In the first year, of primary importance is the removal of heaps pushed up during construction. If possible these should be burnt during the course of the normal maintenance. Of secondary importance is the removal of regrowth and potential lignotuber regrowth, particularly in mallee Eucalypt areas. Blade ploughs have been found to be effective in mallee country, while in higher rainfall areas repeated ploughing appears to be the only method that has any success. The root systems brought to the surface need to be gathered together and removed from the firebreak. This may be done using first a pin-wheel rake and then a dump plough. If finance does not allow this whole procedure to be carried out in the one year, then it should be completed in the following year. It is estimated that a concentrated effort in the first three years of maintenance is required to control lignotuber regrowth. Once this problem has been brought under control the frequency of maintenance can be reduced providing firebreaks are not suffering yearly weed invasion. Frequency may be reduced to once every two or three years, ploughing being alternated with scarifying, which does not disturb the sub-soil as much as ploughing, interspersed with years of no maintenance.

A knowledge of rainfall in the area will aid in estimating maintenance needs, but surveys should be carried out to verify these. Surveys may be done by Wildlife Officers on their regular patrols, or by the contracted reserve neighbour.

In sandy soils the time taken to control lignotuber regrowth should be minimised to reduce possible erosion problems. After the initial control of regrowth, the use of herbicides should be considered. If this does not seem advisable, then ploughing should be limited and scarifiers introduced as soon as possible. For internal breaks on sandy soil time between disturbing the firebreak may be increased to once every three years after initial regrowth control is achieved.

Time of Maintenance

Timing of maintenance is dependant on the ability of machinery to work the soil. This in turn is dependant on soil moisture content. There must be enough moisture to allow ploughing particularly in hard setting clays , yet not too much, which may cause bogging. Sands and loams are less restrictive in this regard.

Rainfall affects vegetation growth rates. In higher rainfall areas where growth rates are higher, the frequency of maintenance may be yearly to control regrowth.

In general terms maintenance is best carried out in the spring, though in wetland areas this may be delayed till mid summer before conditions are suitable for machinery to move. The specific time for maintenance should be left to the discretion of the reserve neighbour contracted to carry it out, as he should know the local conditions.

Wherever possible maintenance should be completed before the start of the fire season so that firebreaks are in their best condition at the time of highest fire risk. Maintenance should be avoided during the fire season as this may increase the risk of fires starting on nature reserves.

LOW FUEL BREAKS

There are two types of low fuel breaks, those slashed, and those periodically burnt to reduce the amount of vegetation. Both function as firebreaks by reducing amounts of fuel available to a wildfire and reducing intensity which slows the fire's rate of spread. They also provide access to areas which may be safely back burnt in the face of a wildfire.

Slashed Breaks

These low fuel breaks are constructed mainly in heath vegetation by tractor drawn slashers. They cannot be easily constructed in areas that support vegetation with woody stems above 25 mm in diameter as the slasher does not have the ability to cut through larger stems. From this it appears that slashed breaks are confined to heaths and coastal heaths where tree forms are small and bushy. The major advantages of this type of firebreak are that it reduces to negligible proportions the erosion problems common to the sandy soils on which these vegetation types occur, and it can be constructed successfully on slopes that would not support a bare earth firebreak.

It achieves these advantages in three ways. Firstly the soil surface is not unduly disturbed and the very unstable sub-soil is not exposed to the effects of wind and water erosion. Secondly, the root systems of the plants are not removed and continue to hold the surface together. Thirdly, the existence of the remaining vegetation helps to reduce the effects of wind erosion.

The more stable soil surface provides better access for vehicles, which is the most significant benefit of this type of firebreak. The disadvantages of the slashed firebreak are the initial increase in cured fuel which may support a wildfire, and the accompanying higher fire risk in the areas until the slashed vegetation decays. To maximise the decomposition rate of the slashed vegetation the timing of the construction and maintenance are important.

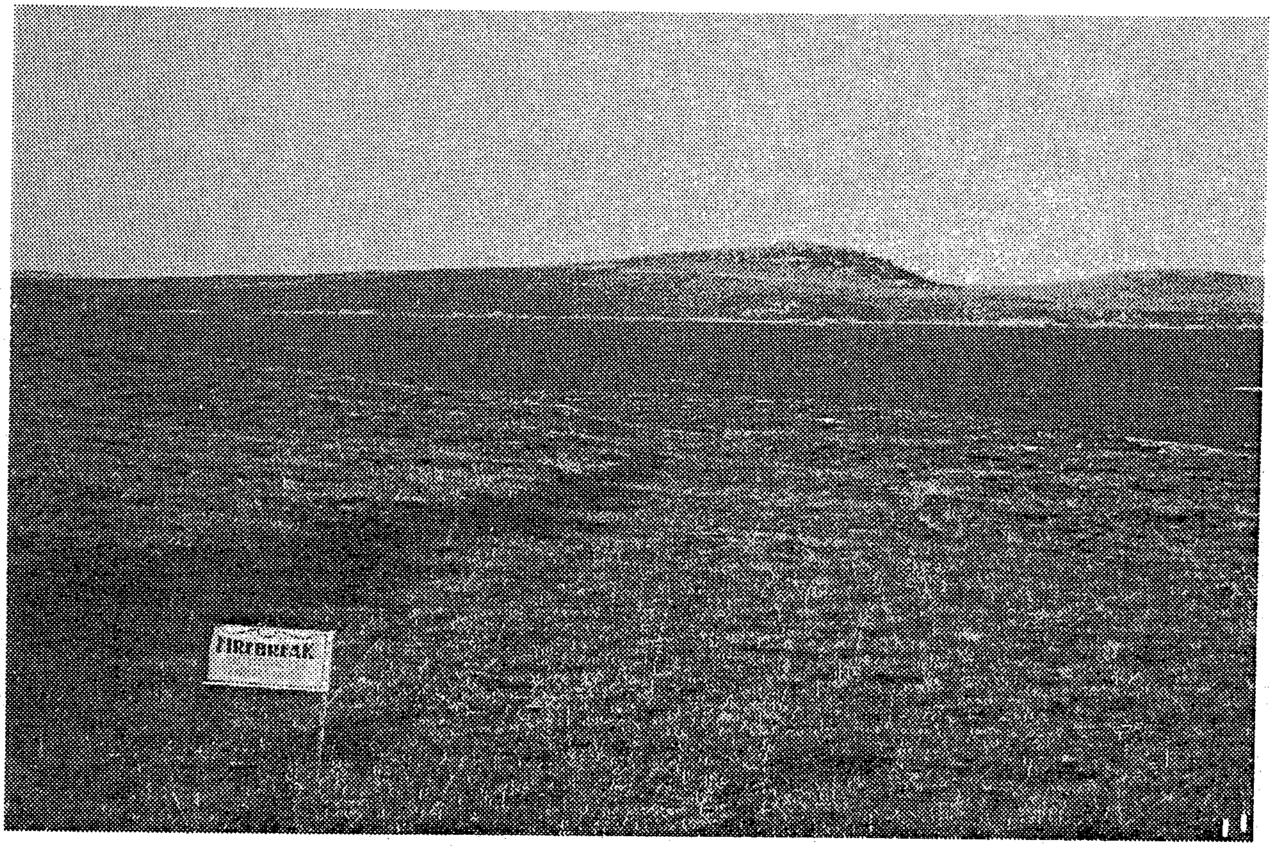

Fig. 10. A slashed low fuel firebreak constructed in coastal heath vegetation on very unstable sandy soil. A bare earth firebreak on this slope would not be viable.

Burnt-Breaks

Low fuel firebreaks that are constructed by using fire require large numbers of personnel to ensure that the control burn does not escape as a major wildfire on the reserve. It also requires the construction of two bare earth firebreaks, one either side of the area to be burnt. These firebreaks are very expensive in terms of manpower, machinery hire and loss of conservation values.

The actual techniques for safe control burns are well documented elsewhere and will not be dealt with here.

The advantages of this type of firebreak are that the level of fuel is reduced very quickly, and there is no extended increase in fire risk as with slashed breaks. Cool spring burns which do not totally remove all vegetation are recommended. The advantage of this is to retain the low fuel break as a barrier to wind borne soil, seeds and fertilizer.

Burnt low fuel firebreaks can be placed in most topographic areas, the only restriction being the need to have bare earth breaks or tracks defining the low fuel area. In this case the factors affecting the placement of bare earth breaks will limit the placement of burnt low fuel firebreaks.

The disadvantages of this firebreak type are the increased fire risks to the reserve from escaped control burns, and their increased costs. These two factors indicate that caution should be taken when proposing the construction of burnt low fuel firebreaks. It would appear that the conservation values to be protected need to be of the highest order.

Time of Construction

Slashed breaks

It is thought that the late autumn is the best time to construct these firebreaks as the winter weather will help in the breakdown of the slashed vegetation and slow the rate of curing, thus reducing the fire risk. Impact of construction on plants is also thought to be less at this time as the winter will allow plants to recover from the shock.

Burnt breaks

Control burns are best in early spring when low intensity burns are more easily controlled and do not remove all the vegetation from the fire-break. Meteorological considerations such as wind direction and speed, temperature, moisture content of the fuel and the humidity should be kept in mind to choose the best possible conditions to carry out the burn with the least likelihood of it escaping onto the reserve as a wildfire.

Maintenance

Slashed breaks

Slashed breaks are maintained by the same method as they were constructed. The factors most meaningful in maintaining slashed breaks are the frequency and the height of the blade from the ground. After the initial construction of slashed breaks the amount of litter caused by the cut will be greatly reduced. This will reduce fire risk substantially in the years after the initial construction. It has been found that, by maintaining these firebreaks yearly, a thinning out process had begun through the loss of certain plant species, particularly those that set seed in woody fruits. This problem may be overcome in two ways. The frequency of maintenance may be increased to every two years allowing plants to flower, set seed and to disperse the seed. The other method involves raising the height of the slasher, allowing flowering to take place on old wood and to disperse seed the next year as the seed capsules will be below the level of the slasher's blades. It is hoped in this way to allow seedlings to stop any thinning of the breaks which may lead to erosion problems.

As a majority of plants in heath vegetation are spring flowering, this season should be avoided for maintenance.

Burnt breaks

The method of maintenance is the same as construction. The time at which maintenance is carried out will depend on the type of fire required; low intensity fire during spring, and hotter more intense fires during late autumn. The desired amount of fuel to be left in the break should first be planned and the appropriate type of fire and season used.

It is suggested that the less intense spring fire would serve fire control management admirably, being less likely to escape as a wildfire, and leaving more vegetation to act as a barrier to weed invasion.

COMPOSITE BREAKS

An increase in the effectiveness of the total firebreak system may be achieved if natural firebreaks are complemented with man-made breaks. This increase in effectiveness is achieved without increasing the disturbance of conservation values of reserves, and requires only that careful planning occurs before a firebreak system is constructed. However, these systems should only be constructed where little if any increase in expense is involved. Where major re-alignment is required to incorporate natural firebreaks the expense may not be warranted as the natural features will continue to serve as firebreaks regardlessly.

PLANNING PROCEDURE

In planning firebreak systems the initial steps should be to gather together the appropriate topographical and cadastral maps, a stereo pair of the most recent aerial photography of the reserve, and Landsat images of the area for as many years as possible. From this material a proposed firebreak system may be put forward. An inspection of this proposed route should then be made on the reserve to ascertain its feasibility. Such matters as the actual topography, slopes, stream crossings, natural firebreaks, watering points, soil types, vegetation types and their fuel loadings and the presence of rare flora and fauna should be looked into.

Flora samples along the whole of the proposed route should be collected with appropriate data. Any suspected rare flora should be left undisturbed and clearly marked on the ground so that a botanist may relocate it to determine its species. It is important that the whole length of the firebreak system be surveyed and marked at this time.

While in the area of the reserve, discussions with reserve neighbours should take place, ascertaining their desired level of firebreaks for the reserve, and the availability of machinery to carry out maintenance once the system is constructed.

Should the firebreak route require changing, this should be done back in the office, first as a proposed route that will need to be re-surveyed. Where no change is required, construction can follow the marked line as left after the initial survey.

While supervising the construction of firebreaks, officers will not always be involved immediately. During these times data should be collected for the reserve. Such things as a bird list, samples of flowering plants should be taken, and any reptiles and mammals disturbed during the course of firebreak construction should be noted. This is particularly true for ground burrowing animals that may be brought to the surface at this time. In general the maximum use of time is to be sought.

It is felt that careful planning should ensure that a firebreak route be surveyed no more than twice.

SECTION THREE: POLICY

The following are proposed guidelines arrived at after consideration of the preceding discussion.

- The disturbance of reserve habitats by the construction of firebreaks be kept to a minimum.
- The maximum area of any reserve committed to the construction of firebreaks be no more than 2%.
- The minimum width of firebreaks to provide two-way access to fire-fighting and maintenance vehicles, and comply with the required minimum width of the relevant Shire.
- No firebreak to be constructed through a known dieback area and, where dieback is suspected in an area, no work to proceed until samples from the area have conclusively shown negative results.
- All new firebreak routes to be surveyed for rare flora. No rare flora to be disturbed in the course of firebreak construction or maintenance.
- All new firebreaks to be planned in consultation with reserve neighbours.
- Maps of firebreak systems to be drawn showing firebreaks, access points, water points, status of neighbouring land. Stereo aerial photography of the reserve to be kept with a master copy of this reserve map.
- Natural firebreaks to be incorporated into firebreak systems wherever feasible.
- Construction of firebreaks on slopes to be avoided wherever possible. Where this is not possible, the most direct route down the slope to be followed if it is not greater than 1:15. Water drainage provisions should be made at the time of construction. Where a direct route would take the slope above the recommended maximum, the firebreak to follow the most level course.
- Perimeter firebreaks to follow reserve boundaries as closely as possible. Where a reserve boundary is ill defined and borders land likely to be released as farm land, the boundary should be surveyed. Perimeter breaks to be of bare earth, and where conservation values require it, be complemented by low fuel breaks.
- Internal firebreaks to be the maximum width that the 2% area figure allows after considering the maximum width of the perimeter breaks.

Safe access and ability to back burn in the face of a wildfire to be primary considerations. The type of firebreak chosen to be in response to soil type and the desire for safe access.

- The minimum compartment size formed by internal firebreaks to be 100 ha.
- Formation of compartments to maximise the number of seral stages of dominant vegetation associations on any particular reserve. Cost factors may require that the number of internal breaks and compartments be reduced below the allowable maximum, as the added advantages may be minimal in very large reserves.
- Detailed records of construction and maintenance to be kept, showing type of equipment used, time of year, cost, condition of firebreaks before and after maintenance.
- Rates for contracting to be adopted from the Department of Agriculture's Farm Budget Guide or other similarly recognised set of rates.
- The Wildlife Officers of the Department of Fisheries and Wildlife be requested to carry out inspections of firebreaks while on normal patrols. A report to be submitted informing the Reserve Management Section of the condition of the firebreak. Noxious weeds and weed invasion to be noted in particular and a map identifying the area to be submitted with the report. Noxious weeds to be removed and destroyed immediately they are discovered.

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