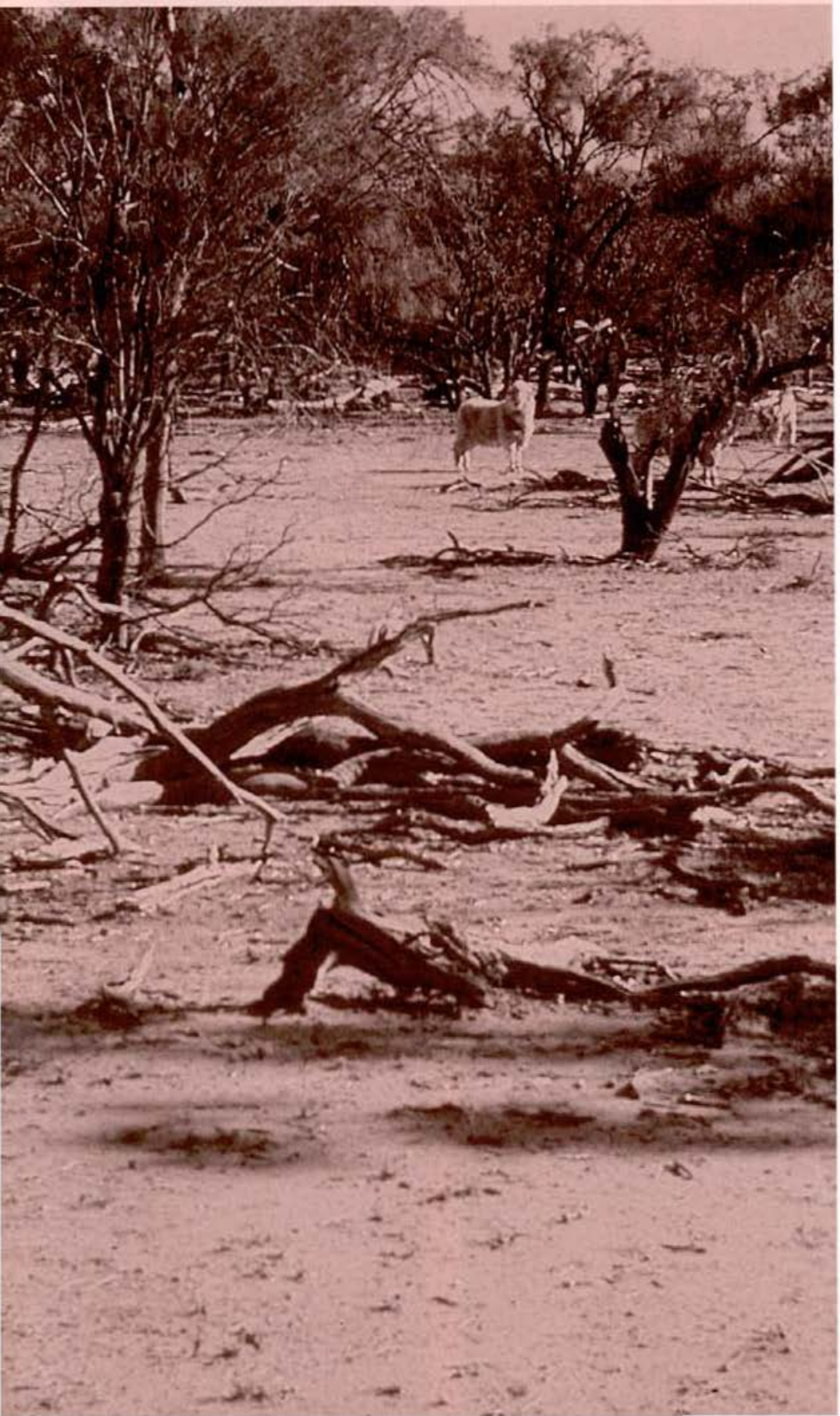
Fire *v.* shrubs in the semi-arid rangelands

'...the natives were about, burning, burning, ever burning; one would think they were of the famed salamander race, and lived on fire instead of water. The fires were starting up here and there around us in fresh and narrowing circles...' (Ernest Giles, 1889)



The firestick is an ancient tool. It was central to the Aborigines' way of life, and they used it regularly to set fire to the country.

In contrast, European settlers feared the effects of fire on life and property, and disapproved of the apparently casual use of fire by Aborigines. Ironically, we can now see that the early colony's vital pastoral industry depended upon the grasslands that these countless fires created.

Nowhere is that dependence more evident than in the semi-arid woodlands of eastern Australia. This vast tract of waterless country — covering some 500 000 square kilometres — once presented a park-like appearance, with unending stretches of perennial native grasses (such as kangaroo grass and blue grass) scattered with trees and shrubs.

Now, little more than a century after the first settlers turned their sheep and cattle onto this country, much of it is dominated by noxious and inedible shrubs.

The density of these 'woody weeds' — such as turpentine, punty, and hopbush — has been insidiously increasing, and the palatable perennial grasses have been largely replaced by annuals like spear grass and wire grass, which make for poor pasture.

According to Dr Ken Hodgkinson of the CSIRO Division of Wildlife and Rangelands Research, about 25 000 square kilometres of semi-arid country has been 'shrubbed out' and has become extremely difficult to reclaim. The remaining country is at risk unless prescribed burning begins soon.

As an indication of how quickly the problem can worsen, Dr Graham Harrington, Officer-in-charge of the Division's Rangelands Laboratory at Deniliquin, N.S.W., found that an ungrazed paddock near Cobar had 5800 shrubs per hectare in 1974, and that by 1977 their numbers had increased by 45%.

Not only has the sheep-carrying capacity of the land fallen by up to a half, but dense shrub cover is making it extremely difficult for graziers to find their sheep, and even for rams to find ewes. So flock management is deteriorating, especially for routine tasks such as control of blowfly strike. Wool yields have diminished, lambing rates have become barely sufficient for replacement, and, of course, profits have evaporated.

Mr Mike Young of the Division has investigated the economic and social impact of shrub invasion, and found that a rapid population decline has occurred in the most severely shrub-infested regions. He esti-

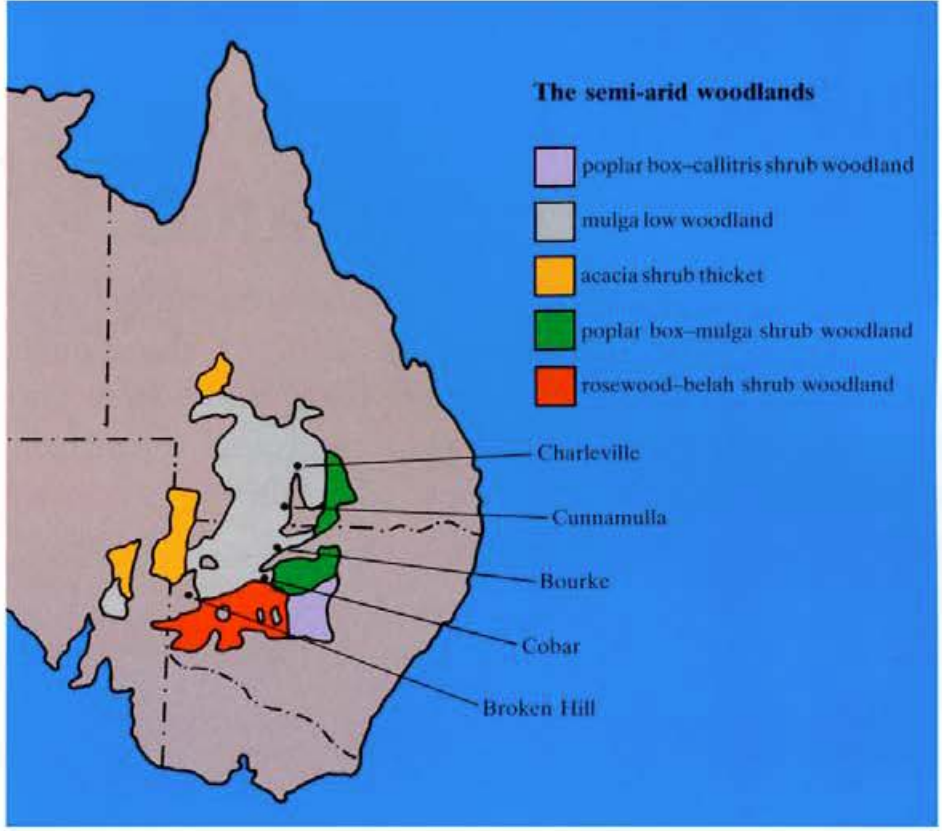
Grazing often removes so much of the grass fuel that fire is impossible.

mates that, every week between 1971 and 1976, one property-owner sold out to his neighbour and 11 people left the country for the towns and cities. Amalgamation of holdings has become necessary to provide additional area for fewer sheep.

There is little doubt that lack of fire is to blame. Yet graziers still show a reluctance to use fire to halt the shrubs' advance.

Unfortunately, this reluctance to burn, unwittingly inappropriate, may have allowed the shrub invasion to pass the point of no return in some areas, thinks Dr Hodgkinson. Replacement of grass by shrubs, combined with a run-down in the condition of the remaining pasture due to overstocking and soil erosion, means that fuel loads now rarely build up to a level where they can carry fire.

At least 900 kg of grass fuel per ha is required for fire to propagate in this country. Shrubs alone will fail to carry a fire. Dr Harrington's studies in the wildfire-prone summer of 1975/76 showed that, without shrubs, the quantity of grass fuel peaked at 1500 kg per ha; on shrubby sites, grass could not get above 200 kg per ha. Because of this, recent computer simulations by Mr Young predict that it is now too late for many existing graziers to stave off bankruptcy (see the box on page 7).



Advancing shrubs are a problem throughout the semi-arid woodlands.

A sorry history

The core of the shrub-problem country lies between Cobar and Bourke in the central west of New South Wales. But the problem extends over most of the semi-arid rangelands, a region that receives only 300–700 mm of rain a year. Even during winter, evaporation potential exceeds rainfall by 2–5 times.

The area is bounded on the south by the Riverina and on the east and west by the Lachlan and Darling Rivers, and extends north into south-western Queensland. It was one of the last areas of these States to be settled, between 1840 and 1880.

When the squatters arrived they established frequent watering points for their stock, and kangaroos utilized the water as well. Previously, kangaroos had been generally confined to the better-watered regions; with water available, their range and numbers increased considerably.

Parallel with this, the spread of rabbits through the region during the 1870s and 1880s coincided with a run of flush seasons, which gave the graziers an erroneous impression of the carrying capacity of their newly settled land.

Heavy grazing suppressed grass fires by preventing the build-up of sufficient fuel. If any fires did occur, they were brought under control as soon as possible by graziers who didn't want to lose fences, buildings, and valuable fodder.

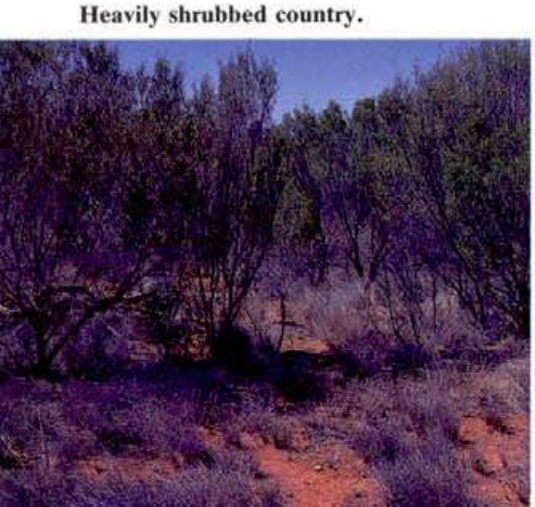
The vegetation was grazed by ever-increasing flocks, and fast-growing numbers of rabbits and kangaroos. Pastoralists had optimistic ideas about the size of the resource, and vastly over-estimated its potential for meat- and wool-production. During the last three decades of last century, overseas companies and banks established large enterprises to exploit the promised riches.

The crash came at the end of the century when a series of droughts caused massive livestock losses and financial disaster, bringing about a Royal Commission in 1901. The Commission brought to light evidence of how the country had become run-down.

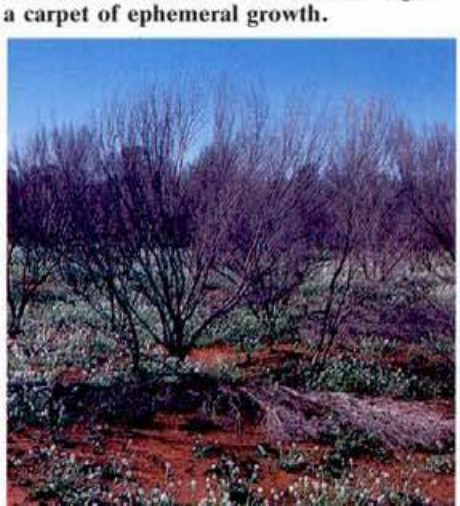
Fuel loads now rarely build up to a level where they can carry fire.

Intensive grazing pressure had soon reduced pasture vigour. Watering points had allowed stock to exert excessive grazing pressure during drought. Grasses were killed, and soil was compacted. Some areas suffered permanent loss of topsoil and

Heavily shrubbed country.



The same spot 6 months after a burn. The shrubs have died, and rain has encouraged a carpet of ephemeral growth.



Six years later, and annual grasses predominate across the same stretch of country.

nutrients. In the absence of fire and competition from perennial grass, shrubs took over.

Searching for answers

If the shrubs' advance, continuing to this day, is to be halted, then careful re-introduction of fire into woodlands is the only way, according to the CSIRO scientists.

Their work began in 1967, after graziers had requested CSIRO to find a solution to the shrub problem. Mr Ted Moore of the then Division of Land Resources Management began work in the Cobar area, and his fire studies demonstrated that burning could control shrubs, and that further such studies were justified.

The Queensland Department of Primary Industries and the Soil Conservation Service of New South Wales also commenced shrub-control studies in the late '60s.

From 1973, CSIRO devoted more effort to the shrub problem, and investigated

The difference that fire makes. Several years ago the track along this fence prevented a fire from burning the area on the left.

alternative strategies, such as grazing by goats, herbicide sprays, and mechanical clearing. All proved too expensive and unreliable for large-scale shrub control.

Following the wet years of 1974 and 1975, an abundance of grass bred many wildfires, renewing interest in the effect of fire, and how it could be used as a management tool. The CSIRO scientists began fire studies at Coolabah, Wanaaring, and Yantabulla, and continued those at Cobar.

During the summer of 1979/80, they conducted several large burns involving areas from 300 to 2000 ha. These showed that fire killed approximately 80% of the small shrubs (less than 20 cm high), and 20–30% of the larger ones.

From the various studies that have continued since then, the scientists involved now believe they have a good understanding of fire's effects on the ecology of the region, and strongly advocate its use in maintaining the country as rangelands.

Although periodic wildfire is a natural phenomenon in the rangelands, this does not mean that deliberate prescribed fire can be utilized lightly. The scientists' research has shown that fire is a powerful but imprecise tool, and must be used with care and understanding.

Because of the inherent risk associated with burning large areas, they have also made a point of examining fire behaviour (see the box on page 6).

Fire here is rare

The first thing to notice about fire in these rangelands is that it is a rare event; mostly you cannot get this country to burn even if you try. Only an unusually wet season will produce sufficient fuel to carry it. This contrasts strongly with eucalypt forests, where each summer brings danger of wildfire.

The time between successive rangeland wildfires is likely to be very long — perhaps a quarter of a century or even more in seriously degraded areas, whereas before settlement the fire interval was only 5–10 years. Grazing has reduced the vigour of perennial grasses and allowed shrubs to establish. Once the shrubs have matured, they displace the remaining perennial grass, and fires must then depend upon the appearance of ephemeral grass in exceptionally wet years.

Furthermore, if a wildfire does start, graziers put it out as soon as they can. The

The park-like appearance of semi-arid woodland when free of shrubs. Here poplar box (*Eucalyptus populnea*) dominates.

last extensive wildfire in poplar box woodland occurred in 1921 when country between Narromine and the Darling River was burnt out. As far as the scientists can determine, the heavily shrubbed region between Cobar and Bourke was not capable of carrying fire again until 1984. The above-average rainfall of 1973 and 1974 led to wildfires that raged throughout nearly 2 million ha of mulga country to the west, but these failed to spread into poplar box country, as the fuel was too patchy.

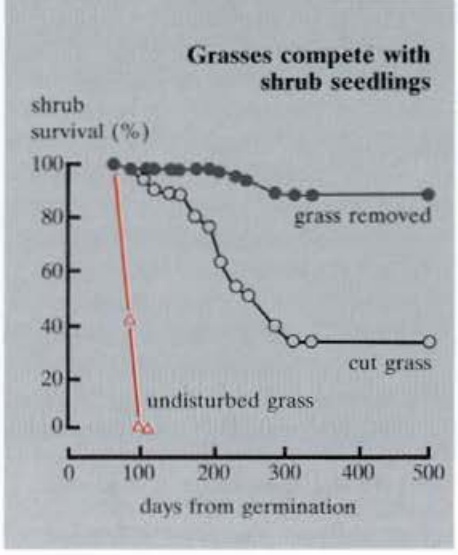
The other important thing to realize about the rangelands is that the same infrequent wet seasons that are a precondition for fire also promote the widespread germination and establishment of shrubs. In the Cobar region, major episodes of shrub establishment have been confined to 1920, 1956, and 1974 — all periods of above-average rainfall.

According to Dr Harrington, the recognition of these critical periods is the key to effective shrub control. If fire is allowed to occur whenever the country is able to burn (after infrequent high-rainfall periods, occurring perhaps only once in 25 years or so), then that fire will kill nearly all the young shrub seedlings, and some adult shrubs too. Grasses will spring back rapidly after the fire.

When shrubs are burnt

A large number of experiments over the last few years have confirmed the soundness of these ideas. The scientists have examined the effect of fire on the mortality of different shrub species of various ages, and at different times of year. They have looked at the effect of soil moisture, and the ways in which shrubs and grass compete for it. And they have studied the effects of various fire intensities.

One particularly clear result, shown in the graph on page 7, came from an experiment in which Dr Hodgkinson looked at the survival after fire of three of the main shrub species — mulga, punty bush,



Competition from grasses can drastically reduce shrub survival. The graph shows how narrow-leaf hopbush seedlings fared in an experiment involving the grass woollybutt (*Eragrostis eriopoda*).

and budda. Despite large variation in the fire resistance of the mature shrubs, seedlings of all three species were totally wiped out.

While fire promotes the germination of some shrub species, for these to survive the seedlings need good rains after the fire, and these events rarely succeed each other.

Many shrub species are fire-resistant, having evolved in a fire-prone environment (before the Aborigines, lightning must have set the countryside aflame whenever fuel levels built up). After a fire, these plants either resprout from the base of their stems, or drop a load of seeds.

Furthermore, Dr Harrington has shown that seed numbers in the soil are drastically reduced by burning. Shrubs in paddocks burnt in 1979 were still showing the effects of such treatment in 1984 and produced only half a million seeds per ha, whereas unburnt paddocks ran to nearly 2 million. Timing a burn in 1984 to catch the seeds on the bush reduced this seed harvest to virtually zero.

On balance, shrubs fare much worse by being burnt than not — young shrubs are destroyed while mature shrubs are reduced in number, size, and regeneration potential. The localized influence of enhanced germination is negligible compared with the general trend of shrub reduction.

Dr Hodgkinson has determined in one experiment that, when rain arrives on the rangelands, pasture regrowth on burnt areas may be up to three times greater than that on unburnt country. Whenever burning achieves a significant reduction in shrub biomass, pasture growth can be expected to improve for at least the next 10 years, and probably longer.

A significant finding has been that the intensity of a fire has little effect on shrub mortality. In experiments where, by spreading straw over the ground, the fuel load has been artificially raised from 300 g per sq. m to 800 g, Dr Hodgkinson has seen little difference in the outcome between low-intensity and high-intensity burns.

In other words, any sort of fire, provided it can persist, will do. This is good news, for it means that low-intensity prescribed burns are effective.

Reluctance to burn

Yet prescribed burning remains foreign to the semi-arid rangelands. Dr Harrington and Mr Ross Sawtell of CSIRO have been collaborating with New South Wales State agencies in waging a long, but largely fruitless, campaign to convince landholders of the desirability of fighting shrubs with prescribed burning.

Some plants, such as turpentine, resprout from the base after fire. Despite such a strategy, fire always favours grasses in the battle for dominance.

Fire as a management tool

Using fire as a tool to control shrubs in the semi-arid rangelands is not difficult, say the CSIRO scientists, if the area can be persuaded to burn at all.

Dense shrub growth will not burn unless it has a thick layer of grass or litter beneath it. And the fire will not carry if gaps in the fuel cannot be bridged by flames.

Fuels such as perennial oat grasses (*Enneapogon* spp.) may burn at loads as little as 800 kg per ha, but fire in tussock grasses normally requires 1500 to 2000 kg per ha. Grass normally has to be well cured before it will burn, but tussock grasses will burn when green because of their high resin content.

Research indicates that even low-intensity fires will defoliate shrubs, and that is all that is needed. The aim should be to achieve a 100% burn-out of the area, although in practice it is rarely possible to achieve such a figure.

For the most successful results the grazier should know when to burn, have experience in determining safe weather conditions, and have adequately prepared firebreaks. Decisiveness in utilizing what are often fleeting opportunities is also needed.

A fire's intensity and rate of spread is related to air temperature, humidity, and wind speed. So, given the right weather conditions, a deliberate burn will be easy to control; under the wrong ones, an uncontrollable wildfire may result.

In the semi-arid woodlands, a wind speed of 7–15 km per hour is ideal to carry a fire, allowing flame from one tussock to set fire to its neighbour.

'Mosaic' burning, where perhaps 30% of a property is burnt, is recommended, rather than burning vast areas at one time. This aids fire control, leaves fodder for stock, and promotes ecological diversity.

Since fuel is rarely sufficient to support a really intense fire, a firebreak 7–10 m wide is usually adequate. Two parallel tracks can be graded and the intervening grass burnt, or natural breaks in fuel can be used — densely treed and shrubbed country without a grass undercover will not burn.

With a fully equipped fire-fighting team assembled, the fire can then be safely lit. The team's job is to watch for any spot fires that might have jumped the firebreaks. Approached with care in this way, the scientists have found, fire can be safely used even on days with temperatures in the high 30s, and winds of 15 km per hour.

With the co-operation of the Departments of Agriculture, Lands, Soil Conservation, and Forestry, together with that of neighbours, prescribed burning can be used as a low-cost and effective tool for shrub control. Even so, the onus rests on the individual landholder to recognize the value of fire, and to use it, since no concerted plan of action has yet been drawn up.

Management of vegetation with fire. K.C. Hodgkinson, G.N. Harrington, G.F. Griffin, J.C. Noble, and M.D. Young. In 'Management of Australia's Rangelands', ed. G.N. Harrington, A.D. Wilson, and M.D. Young. (CSIRO: Melbourne 1984.)

Last season the amount of prescribed burning carried out was 'very disappointing', even though the pasture conditions on many properties offered the first opportunity for effective shrub control since 1921. It was left to the wildfires that burnt out much of the country around Cobar last summer to demonstrate how effective fire can be against shrubs. Dead shrubs can be seen for kilometre after kilometre.

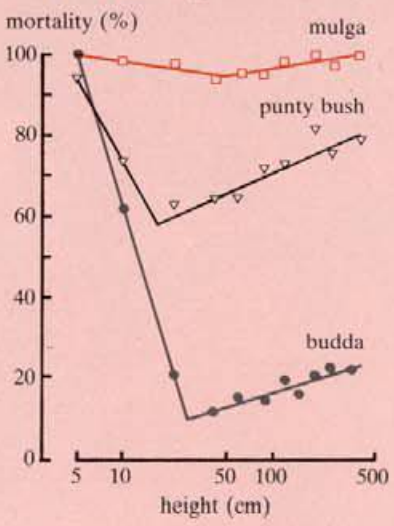
So the shrub problem continues to worsen and, warns Dr Harrington, will continue to do so until fire becomes an accepted part of rangelands management. Why the reluctance?

A large factor may simply be familiarity. It's hard to get into the habit of prescribed burning when suitable conditions arise only at intervals of perhaps 25 years.

When such opportunities are missed, the shrub density builds up, and the quantity of pasture decreases, thereby causing even longer periods between potential fire seasons. Dr Hodgkinson thinks this line of reasoning explains the lack of prescribed burning in 1984. The time available to do it was about 6 weeks, and landholders didn't have the experience to be decisive.

Despite variations in the susceptibility to fire of established shrubs, fire kills virtually all seedlings less than 10 cm high (about 2 years old). Fortunately, the rains that promote seedling emergence also promote a burnable fuel load of grasses.

Fire kills seedlings



Bankrupt — burn or no burn

Mr Mike Young of the Division of Wildlife and Rangelands Research has used a computer to model the net farm income of a typical 4000-ewe property near Bourke, N.S.W. He examined 'burn' and 'no-burn' management strategies, and found that, either way, the shrub-infested property is likely to slide into bankruptcy by the year 2000.

Mr Young looked at four scenarios. The first was the standard for comparison: a shrub-free property giving an average net income of $17 232 per year.

The second postulated a property that began prescribed burning in 1950, before shrubs gained the upper hand. It assumed that shrub-control burns would have taken place on three occasions between 1950 and 1985 — each time following wet seasons conducive to shrub establishment. Mr Young programmed the same rain and fire pattern for the next 35 years as well.

The study assumed that each wave of shrub germination resulted in 25% of the property being invaded, and that burning prevented shrubs from becoming established.

After each hypothetical burn, net farm income received a short-term setback, reflecting the reduced feed supply. But within 10 years the benefits of the burn emerged in improved returns. Averaged over the years, this second property produced an income only $1500 less than that from the ideal property unthreatened by shrubs.

But in the two remaining hypothetical cases, where burning has not been practised before now, the shrubs have taken hold too strongly, and the owner cannot afford the cost of burning. He may just as well let the shrubs take over completely, because either way the economic picture is equally bleak.

The grim outlook presented by Mr Young's computer model. It may already be too late to prevent a property of average size with typical shrub cover sliding well and truly into the red within the next 10 years.

Without the cost of prescribed burns, the annual income of such an unburnt property between 1950 and 1985 has averaged only $1306 below that of the farmer who burned. Shrubs had no effect for the first 5 years after germination, but over the next 10 they annually reduced carrying capacity by 4%, and lambing rates by 2%. The same pattern followed the next rains, and so by 1985 the farmer has unwittingly reached a shrub cover of 50% — a point of no return.

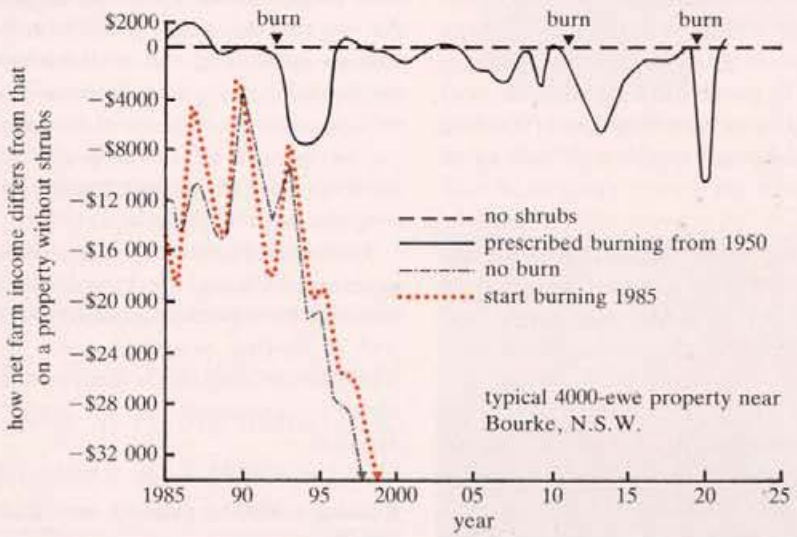
One scenario — the third — projects the same trends over the next 35 years, and sees the property becoming strangled by shrubs. Within 20 years annual net farm return plummets to $28 000 below the shrub-free case.

The fourth scenario assumes that burning starts this year. The grazier burns half of his remaining shrub-free land in 1985 (leaving the other half for his sheep), and burns all the remaining shrubbed country at the next projected opportunity, in 1992. As you can see from the graph, he still goes to the wall by the year 2000.

According to the study, there is only one escape route — expand. If a property carries 6000 or more ewes, then it remains economically feasible to attack the shrub problem with fire. But if its owner procrastinates, economic ruin will befall the property within 25 years.

The results of this simulation clearly indicate the seriousness of the shrub problem. In real life, there will be somewhat different circumstances — future rainfall patterns, degrees of shrub infestation, and so on — and so actual fortunes will fluctuate differently. Graziers with 4000 sheep may survive — or they may be even worse off than predicted here.

Financial effects of shrubs



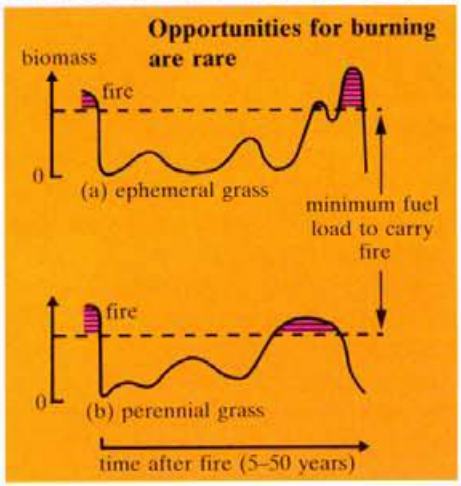
Lighting up a prescribed burn.

Pastoralists are not trained in fire management, and many fear the consequences of fires that may get out of control. Neighbourhood opinion can be a large obstacle too, and some farmers still aren't convinced that fire will have the desired effect. In recent years the New South Wales Department of Agriculture and the Soil Conservation Service have been promoting the use of fire; prior to this there were insufficient research results for such advice to be confidently given.

Another perceived risk of burning off is that the grass consumed by fire could be needed as reserve fodder against drought, which is common in the region. Burning only a fraction of the property at a time may be an answer, but on heavily shrubbed out properties (such as those near Cobar, which for 60 years haven't been capable of sustaining a fire) it's virtually a case of burn the lot now — or never.

General agreement to burn is needed among the community of graziers. If only one does so, the 'green pick' that results will become the target of kangaroos for miles around. Grazing pressure needs to be kept to a minimum after a burn, when grasses are struggling to re-establish themselves against germinating shrub seedlings. It should be possible to keep domestic stock away, but in western New South Wales up to 3000 kangaroos may live within 5 km of a burn.

Burning a 3000-ha paddock near Euston, N.S.W.



In the semi-arid woodlands, sufficient grass fuel to carry a fire occurs irregularly and infrequently. These diagrams show the general picture. Where the principal fuel is cool-season speargrass (a), two consecutive favourable years are required to reach a fuel load that will burn readily. Where perennial grasses dominate (b), burnable levels are seldom reached, but they will persist for 2 or 3 years.

The graph on page 6 shows the results of Dr Harrington's experiment in which narrow-leaf hopbush seedlings were subjected to different amounts of competition with grass, and their survival monitored. As you can see, a full grass cover works well in preventing the establishment of shrub seedlings. Four applications of water — equivalent to 400 mm of summer rain — were required to keep the young seedlings alive. Such wet summers occur only two or three times in a century.

This graph explains why large burns are necessary to keep the kangaroo grazing pressure from becoming locally magnified and destroying perennial grass. It also highlights another factor that has favoured shrub establishment over the years: overstocking.

Burn or perish

But perhaps the main reason why graziers don't prescribe-burn is that they can't afford to. (The dilemma, as explained in the box on page 7, is that they can't afford not to either.)

The economics of arid-land pastoralism are marginal, and although burning is undoubtedly the cheapest way of beating back shrubs, it still costs between 30c and $1.30 per ha, depending on the amount of volunteer labour used. For a typical 1000- to 2000-ha property, these costs are not negligible, and the benefits may not become apparent until 10 years have passed (the time it takes for shrub seedlings to become properly established).

A more significant cost is the likely need, before a burn is even contemplated, to temporarily reduce stock numbers. Unless this is done, there may well be insufficient grass fuel to carry a fire.

As grazing has taken a heavy toll of the once-dominant perennial grasses, the pasture does not respond quickly to summer rain and produce a body of fuel. Fuel production now depends upon the cool-season ephemeral spear grass, and graziers would have to sell or agist stock to preserve this fuel until summer — a very heavy cost for many.

Nevertheless, prescribed burning is the only practical method for controlling shrubs on a large scale, and the CSIRO scientists call on graziers to collaborate with State agencies in introducing the practice before it is too late.

As Major Mitchell concluded in 1848: 'Fire is necessary to burn the grass and but for (it), the Australian woods had probably contained as thick a jungle as those of New Zealand or America, instead of the open forests in which the white men now find grass for their cattle.'

Andrew Bell

More about the topic

The case for prescribed burning to control shrubs in eastern semi-arid woodlands. K.C. Hodgkinson and G.N. Harrington. *Australian Rangelands Journal*, 1985, **8** (in press).

The ecological significance of irregular fire in Australian rangelands. J.C. Noble, G.N. Harrington, and K.C. Hodgkinson. In 'Proceedings, 2nd International Rangelands Congress, Adelaide, September 1985.' (Australian Academy of Science and Cambridge University Press: Canberra, in press.)

Proceedings of a symposium on poplar-box lands. *Australian Rangelands Journal*, 1979, **1** (4); 1980, **2**(1).