WOODY WEEDS IN AUSTRALIAN RANGELANDS: IS PREVENTION EASIER THAN CURE?

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Summary. The difficulties in preventing woody weed infestation of arid rangelands, and the problems associated with their eradication are reviewed. Woody weeds have increased since European settlement and the early recognition of further shrub invasion is essential if this trend is to be reversed. By the time the problem is recognized the invading weeds are often too well established for easy control.

Many woody weed species are susceptible to existing herbicides, but chemical control is not generally practical on large rural holdings. A woody weed control method, such as a period of nil or light stocking over summer to encourage grass growth, ploughing the following spring to sever roots, burning and resowing, may be effective, particularly in more favoured areas.

INTRODUCTION

Prior to European settlement, the rangelands of inland Australia were in a state of dynamic equilibrium (Ross 1969). The nomadic Aborigines lived in harmony with the biological system, even though they used both plant and animal products, and often modified the ecosystem by fire (McArthur 1970).

The arrival of the European has done more to change the natural balance in 200 years than the Aborigine achieved in 30 000 years. McArthur (1970) concluded from historical records that the incidence of fires has decreased since the depletion of the aboriginal population and the introduction of sheep, resulting in increased forest cover and shrub density, particularly in south eastern Australia.

Whilst the introduction of domestic stock and feral animals (particularly rabbits) by the early settlers contributed to rangeland deterioration through exploitation, the Report of the Royal Commission to Inquire into the Condition of the Crown Tenants in Western New South Wales (Anon. 1901) said that these effects were accentuated by an ill advised land tenure system, overcapitalization, low wool cuts and high rents. Similar statements could probably be made for other semi-arid and arid rangelands of the continent. The effects of this mismanagement are now known to include the depletion of soil cover leading to accelerated erosion of the surface soil and loss of available plant nutrients (Charley and Cowling 1968), and an increase in the number of woody shrubs due to their competitive superiority over grasses on infertile soils (Burrows 1976).

This paper reviews the problem of woody weed infestations in semi-arid and arid rangelands, and the encroachment of these species into areas hitherto devoid - or apparently devoid - of them.

WOODY WEED DYNAMICS

There is ample evidence that shrubs are increasing on much of the Australian rangeland under present stock management. Davies and Walsh (1979) found that on Mileura Station (Cue, Western Australia) many species of shrubs increased by up to 250% in the 10 years 1967 to 1976 through natural regeneration and under a stocking rate averaging one sheep to 10 hectares. Similarly in south western Queensland, Burrows (1973a) found that the number of turkey bushes (*Eremophila gilesii*) fluctuated widely, but there was a general increase in numbers over an eight year period in areas protected from domestic stock. Cunningham and Walker (1973) reported differences in regeneration of the inedible turpentine shrub (*Eremophila sturtii*) under grazed and ungrazed conditions, but little difference in the number of mulga (*Acacia aneura*) shrubs which are eaten readily by stock.

Factors other than stocking with domestic animals influence woody weed populations. Wilson and Mulham (1979) recorded lower shrub densities 14 months after a wildfire in the 1974/75 summer near Cobar, western New South Wales though some seedling regeneration was recorded. The latter point is important, since Hodgkinson (1979) recorded seedling densities of about 5 m^{-2} of desert cassia (*Cassia nemophila*) and hop bush (*Dodonaea viscosa*) following 67 mm of rain after a burn compared with 0.1 m^{-2} in the absence of fire. Harrington *et al.* (1979) point out that it is the interaction of rainfall and grazing pressure following a fire which influences regeneration of woody species.

Soil disturbance such as occurs during clearing or the felling of fodder trees during drought, is instrumental in increasing germination and survival of woody weeds. Batianoff and Burrows (1973) found that ploughing of a desert cassia/silver cassia (*C. artemisiodes*) infested area in south western Queensland led to a doubling of shrub density from 5900 to 10 600 plants ha^{-1}, though in a nearby area, Burrows (1973a) reported no regrowth of turkey bush following ploughing. Moore and Walker (1972) found that when trees and shrubs were chemically killed in a poplar box (*Eucalyptus populnea*) woodland at Wycanna in southern Queensland, the density of regenerating trees and shrubs increased from 1967 ha^{-1} prior to treatment in May 1968 to 4017 ha^{-1} on ungrazed plots, but decreased to 517 ha^{-1} on plots stocked with sheep. However, one fire in August 1970 was sufficient to reduce the density of sandalwood (*Eremophila mitchellii*) by 96%, desert cassia by 99% and hop bush by 94%. Working in western New South Wales, Harrington (1979) found that total clearing of a poplar box woodland containing smaller trees of mulga, ironwood (*Acacia excelsa*), wilga (*Geijera parviflora*) and rosewood (*Heterodendrum oleifolium*) led to an increase from 6000 shrubs ha^{-1} to 12 000 shrubs ha^{-1} over three years.

The result of these and other studies indicate that the density of woody weed species is affected by soil disturbance, fire and the grazing animal, and that environmental conditions following disturbance are instrumental in determining whether seedling regeneration occurs.

WHY DO WOODY WEEDS INCREASE?

Burrows (1976) found that both mallee (*Eucalyptus socialis/E. dumosa*)

and mulga communities cycled nutrients, and that organic carbon, total nitrogen and available phosphorus were concentrated in the surface soil. He considered that whilst grasses have an initial advantage during establishment on infertile soils because of their faster growth and phosphorus absorption rates, woody species develop a more extensive root system with time which is instrumental in improving their drought survival and their ability to absorb nutrients. In addition, the woody species are more efficient in utilizing the low levels of soil nutrients, and the dominance of woody plants is accentuated further if grasses are preferentially grazed by stock. Further weight is added to Burrows' hypothesis by the results of computer simulation which showed that soil moisture conditions in southern inland Queensland are unfavourable for woody weed establishment under woodlands, but that following clearing there is a high probability of soil remaining moist for a considerable time in the autumn and winter of years that receive above average rainfall (G.J. Burch, personal communication, 1981). Studies have also shown that temperatures experienced in most of inland Australia during autumn are sufficiently high to enable germination of seeds of many woody species provided soil moisture conditions are adequate (Burrows 1971; Burrows 1973b; Hodgkinson 1979). However, low temperatures in winter may impede this process.

THE SOLUTION?

Woody weeds are recognized as a major problem in Australian rangelands (Moore 1969; Moore 1971; Burrows 1979), and it has been shown that the greater the density of woody plants, the less the grass and herb production (Beale 1973; Walker *et al.* 1972). Woody weeds already occur in sufficient numbers to decrease production of meat and wool in much of rangeland Australia. Their density is increasing, and they are invading areas where woody weeds were not previously a problem.

It is clear that whilst current land use and stock management systems prevail, the encroachment of woody weeds into new areas, and their continued increase in already infested areas will also continue. Any control or containment of woody species must be acceptable to the grazier in both time and overall stock management.

The two major situations which exist at present in areas susceptible to woody weed infestation are:

1. There is already a high density of woody weeds; or

2. there are only a few woody weeds present but because of drastic changes to the ecology - for example the clearing of mulga scrub for drought feeding or encouragement of grass growth - there is the potential for an unwanted increase in their infestation.

Woody weeds already present at high density. Four methods have been used to reduce the density of existing woody species: chemical, fire, mechanical and grazing. Most of the woody weeds present in the Australian rangelands can be killed with chemicals (Robertson 1965, 1966; Batianoff and Burrows 1973; Alchin *et al.* 1979; Burrows 1973a; Condon and Alchin 1979; Young *et al.* 1979) but chemical control is costly, although the development of new chemicals (e.g. hexazinone) may make it economically viable (Alchin *et al.* 1979). Further, the recent development of 'grid balls' of hexazinone increases its potential use in areas suffering a severe shrub problem since they could be aerially dropped on a

grid pattern or thrown out whilst mustering or checking watering points.

Fire is the cheapest of the four methods of control, but its effects are also the most difficult to define. Tothill (1971) found that fire was secondary in importance to grazing as a method of control of *Eucalyptus* spp. suckers, whilst Hodgkinson (1979) and Wilson and Mulham (1979) showed that the ability of shrubs to survive fire differed vastly amongst species.

Mechanical control methods are costly, and their effects too are dependent on species. For example, Burrows (1973a) found that turkey bush was killed by slashing at ground level or ploughing, but ploughing of a mixed scrub of silver and desert cassia resulted in a 100% increase in shrub density (Batianoff and Burrows 1973). The use of a blade plough which cuts roots well below ground level has proved successful in the control of sandalwood and brigalow (*Acacia harpophylla*) suckers in central Queensland. This is a very expensive operation, costing \$55 to \$65 ha^{-1} (J. Scanlan, personal communication, 1980), but it may have a place in rangelands where this expense is warranted.

The use of grazing has not proved very successful, though Tothill (1971) found that provided a spear grass (*Heteropogon contortus*)/kangaroo grass (*Themeda australis*) pasture was grazed, regrowth of spotted gum (*Eucalyptus maculata*), bloodwood (*E. intermedia*) and black wattle (*Acacia cunninghamii*) was no problem. Blackberry (*Rubus fruticosus*) may also be effectively controlled by goats (Vere and Helst 1979). Grazing with either sheep, goats or cattle in more arid regions has not been particularly effective in controlling unwanted woody species (Wilson *et al.* 1976; Harrington 1979; Squires 1980; Niven *et al.* 1980), though goats do have a greater tendency to consume shrubs than either sheep or cattle (Squires 1980).

What then is the answer to the problem of woody weed infested areas? The solution probably lies not in the use of any one method in isolation, but in a combination of two or more methods. It may prove practical to thin out, rather than totally kill woody weeds,with the judicious use of herbicides, mechanical treatment or fire, and sow seed of pasture grasses such as buffel grass (*Cenchrus ciliaris*). Following the initial treatment and sowing, stock would need to be excluded from the area. Exclusion is feasible for domestic animals, but wildlife, and particularly kangaroos, could not be economically excluded. Once sufficient fuel is produced, a fire may be used to further damage the remaining shrubs. Only small areas ($<$ 200 ha) should be developed at a time, and it should be possible to have a number of areas in various stages of development on the one property. This procedure would allow for a reduction in woody weed density and a concomitant increase in pasture productivity. Judicious stocking and the use of fire may aid in maintaining an open pasture and result not only in a slow-down of rangeland deterioration, but also in less fluctuation in annual turnoff of products.

Whatever method is used, it is preferable to attempt control while the unwanted plants are already under severe environmental stress - e.g. at the end of winter in northern Australia when the plants will be suffering from water stress. It is also preferable to attempt control while the woody weeds are less than 50 cm high because at this stage they tend to be more susceptible to herbicides and fire (K. Hodgkinson, personal communication, 1980).

Prevention of encroachment of woody weeds. The disturbance of a woodland often leads to invasion by woody weeds but the extent of this invasion may be reduced by a flexible stocking policy. Following clearing or thinning the area should

not be stocked until regenerating pasture species have matured and seeded. Spelling should be sufficiently prolonged to include one growing period (summer in northern Australia, winter in southern Australia) for it is during this period that up to 80% of grass biomass is produced (Christie 1978). The area may then be conservatively stocked, but it would still be preferable to destock or at least to stock at very light rates for the following two growing seasons. Burrows (1979) advocated heavy stocking with sheep in winter to control regenerating mulga and other woody species in south-western Queensland, as at this time pasture species are reasonably dormant whereas woody species may still actively grow provided soil moisture is available.

It is possible that some woody weeds will establish even if this management regime is followed. In some areas it may be possible to burn in spring or early summer, preferably after significant ($>$ 40 mm) rainfall. Such a fire will not necessarily kill the woody plants but it will at least set them back, and the greater growth rate of the grasses should enable them to be at a competitive advantage for the first few weeks after the burn.

CONCLUSION

There is no simple answer to the question "How do I control these woody weeds?" Chemicals, mechanized equipment, fire, and grazing management all have a place to play in the control of existing populations of woody weeds, but prevention of further encroachment is paramount, and is easier than the cure. In the same way that ignorance of the law is no excuse for breaking it, neither is ignorance of the potential of woody species to invade an area an excuse for neglecting their prevention. It is up to the rangeland scientist to make the implications of various management regimes known to both the land holder and the land administrator and to offer sound advice. It is then up to the land holder and administrator to implement schemes which minimize the risk of land deterioration through the infestation of woody weeds.

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